Water Resource Report 50

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GROUNDWATER AND GEOLOGY OF THE CUMBERLAND VALLEY, CUMBERLAND COUNTY, PENNSYLVANIA

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
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TOPOGRAPHIC AND GEOLOGIC SURVEY
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GROUNDWATER AND GEOLOGY OF THE CUMBERLAND VALLEY, CUMBERLAND COUNTY, PENNSYLVANIA

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by Albert E. Becher
U. S. Geological Survey
Samuel I. Root
Esso Prospecçao Limitada

Prepared by the United States Geological Survey, Water Resources Division, in cooperation with the Pennsylvania Geological Survey

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GROUNDWATER AND GEOLOGY OF THE CUMBERLAND VALLEY, CUMBERLAND COUNTY, PENNSYLVANIA

by
Albert E. Becher [1] and Samuel I. Root [2]

ABSTRACT

Demands on water resources of the northeastern part of the Cumberland Valley have increased 70 percent in the 15 years since 1960. Total use in 1975 was about 25 million gallons per day. Communities and industry west of Mechanicsburg are placing increasing dependence on groundwater supplies and will continue to do so in the future as streams are incapable of meeting increasing demands.

The northern half of the valley is underlain by shale and graywacke of the Martinsburg Formation. East of Carlisle these rocks are partly replaced by large masses of shale, graywacke, and carbonate rock that were transported from distant parts of the depositional basin (informally named transported Martinsburg). The southern half of the valley is underlain principally by a sequence of carbonate rocks about 15,000 feet thick, named the Cumberland Valley sequence. A thick wedge of colluvium masks the older rocks in this sequence on the north flank of South Mountain, in the southern part of the valley west of Mechanicsburg. A similar and correlative sequence of rocks named the Lebanon Valley sequence occurs in the extreme southeastern part of the area. Folds, faults, joints, and cleavage structures related to the South Mountain anticlinorium dominate the principal sequence, but are truncated in the east by later structures of the Lebanon Valley sequence. Steep thrust faulting and overturned folds occur throughout the area, but are most intensively developed in the east.

The Conodoguinet and Yellow Breeches Creeks drain the area and flow eastward into the Susquehanna River. Most of the carbonate rocks and almost all of the shale are drained by Conodoguinet Creek. South Mountain and much of the eastern quarter are drained by the Yellow Breeches.

About half of the precipitation that falls on the area becomes evaporation or transpiration. Groundwater contributes about 80 percent (0.86 million gallons per day per square mile) of the total streamflow derived from the carbonate rock terrane, and about 55 percent (0.59 million gal-

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lons per day per square mile) from the shale terrane. Colluvium along the flank of South Mountain provides extra storage for the southernmost and oldest carbonate-rock units, maintains relatively constant groundwater levels, lowers flow peaks, and helps maintain streamflow during drought in the Yellow Breeches basin. This area has the greatest potential for groundwater development with the least effect on streamflow and water levels.

The specific yield of the zone of fluctuation in the carbonate aquifer is about 0.05. Estimates of transmissivity of the carbonate aquifer range from 500 to 14,000 square feet per day. Average transmissivities are 50 square feet per day for the transported Martinsburg Formation, 200 square feet per day for the transported carbonate rocks, and 100 square feet per day for the normal (in-place) Martinsburg. Interference between pumping wells will be severe, moderate, or minor at spacings of 100, 500, and 1,000 feet apart, respectively, based on average transmissivities and pumping rates of 50 gallons per minute in the Martinsburg and 100 to 1,000 gallons per minute in the carbonates.

The median sustained yields of single wells in the carbonate rocks, in gallons per minute, calculated from specific-capacity data, are: Tomstown, 1,000; Waynesboro, 170; Elbrook, 220; Zullinger, 82; Shadygrove, 26; Stonehenge, 57; Rockdale Run, 400; St. Paul, 82; and Chambersburg, 11. Single wells may sustain maximum yields of 2,000 gallons per minute from the Tomstown and Elbrook; 1,000 gallons per minute from the Waynesboro, Zullinger, Rockdale Run, and St. Paul; and 200 gallons per minute from all others except the Chambersburg. Calculated median sustained yields are 48 and 15 gallons per minute, respectively, for the transported Martinsburg carbonate and noncarbonate rocks, and 28 gallons per minute for the normal Martinsburg rocks. The basal limestone of the Martinsburg Formation is barely capable of supplying domestic needs.

The hydrologic system is strongly influenced by the geology. Locations of streams and large springs and the yielding characteristics of rocks are largely dependent on the areal distribution of rock types and structure. The north-south-oriented diabase dike through Boiling Springs acts as a subsurface dam that separates eastern and western parts of the carbonate aquifer. Gains and losses of water in spring-fed streams in the carbonate aquifer are related to folds, faults, diabase dikes, and other geologic features.

Joints, faults, and solution-enlarged openings are the most important yielding zones in the carbonate rocks, but cleavage probably provides most of the water-bearing openings in the Martinsburg Formation and in the shale zones of the Elbrook and Waynesboro Formations.

Wells drilled on fracture traces or in topographically low positions have significantly greater yields than other sites, as shown by specific-capacity

data from seven wells on fracture traces and 174 wells in various topographic positions.

Water from all rocks contains mostly calcium, magnesium, and bicarbonate in solution, is generally hard to very hard, and is slightly acidic to alkaline (pH ranges from 6.6 to 8.2). The results of 106 analyses indicate that groundwater in the area is generally of good chemical quality. Concentrations of iron, manganese, and hydrogen sulfide in excess of standards set by the U.S. Environmental Protection Agency are relatively common in the Martinsburg and Chambersburg Formations. Only 5 percent of the samples from the carbonate aquifer contained nitrate in amounts greater than the Environmental Protection Agency limits. Moderate levels of nitrate (4 milligrams per liter as nitrogen) in most samples indicate a growing and potentially serious problem for the future. A spill of gasoline in 1969 (226,000 gallons recovered) contaminated the groundwater in one small drainage basin. Gasoline was trapped in shallow, isolated openings in the bedrock and could be recovered only when water levels declined, allowing the gasoline to move into pools through lower interconnected passages. The groundwater there is also contaminated by high concentrations of iron, manganese, and lead.

The major groundwater problems in the area are, first, increasing chemical and bacterial contamination of the carbonate aquifer, especially where land use is most intense, and, second, the flooding of man-made subsurface structures by groundwater during periods of high natural recharge.

INTRODUCTION

This report presents the results of a study of the geology and hydrology of the northeastern part of the Cumberland Valley (Figure 1). It describes the hydrologic system and how it functions within the geologic framework, defines the areal limits and yielding potential of the rocks underlying the valley, discusses the results of well-site-selection studies, and describes the quality of the groundwater. The study was undertaken to provide groundwater information for planning and water-resource development, and for an environmental study on the metropolitan Harrisburg area east of Mechanicsburg (McGlade and Geyer, 1976).

Information in this report can aid planning organizations, municipalities, rural communities, consulting geologists, engineers, well-drilling firms, and industry in their efforts to develop or manage the water and land resources of the valley. Individuals interested in drilling water wells for homes or farms can determine the chance of obtaining an adequate supply, select favorable well sites, predict optimum drilling depths, and anticipate development problems.

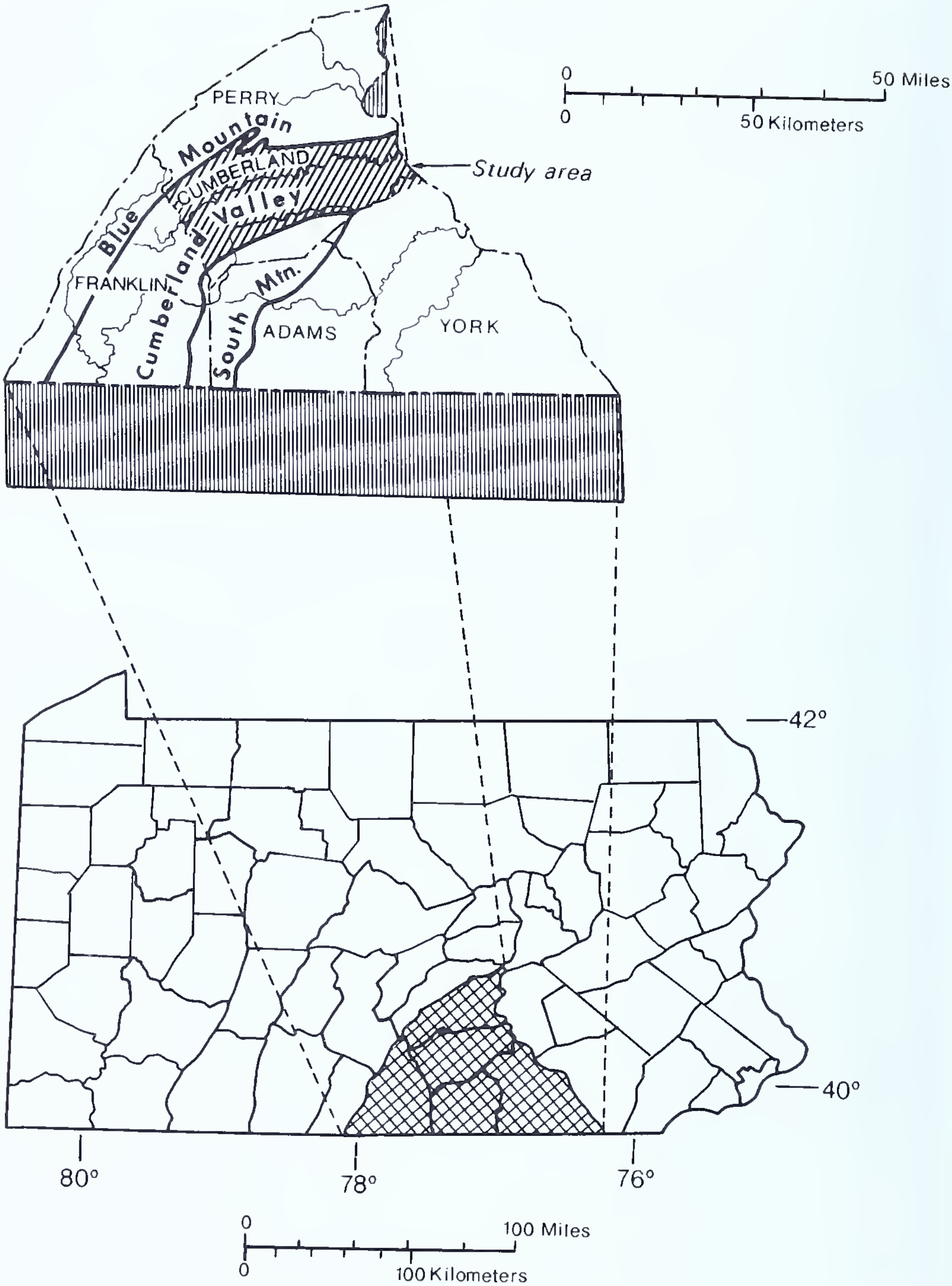

Figure 1. Map showing the location of the study area, the Cumberland Valley, and the immediate vicinity.

WATER USE

Water use in 1975 was about 25 Mgal/d (million gallons per day) and was divided between the categories shown at the top of the following page.

Use	*Amount (Mgal/d)*
Public supply	20
Self-supplied industry	2.3
Rural residential	1.5 (estimated)
Livestock	1.0 (estimated)
Irrigation	.2 (estimated)

Based on these figures, public-supply systems provide 80 percent of all the water used. Table 1 lists these systems, their water sources, 1960 and 1975 use, and population served. Public-supply systems serve 82 percent of the total population and 88 percent of the population of Carlisle and the area to the east. West of Carlisle only 53 percent is served by public-supply systems. Water use has increased 72 percent between 1960 and 1975 in public systems for which data were available.

Water from the Susquehanna River, and, to a lesser extent, from the Conodoguinet and Yellow Breeches Creeks, can satisfy the public-supply and industrial demands of areas east of Mechanicsburg. Farther west, surface-water sources become less adequate and more expensive to develop. In these areas groundwater will be increasingly sought to satisfy the expanding water needs created by regional growth.

DATA BASE

A geologic map was compiled from field mapping done during the study and is shown on Plate 1. Records of about 650 wells and 30 springs are given in Tables 13 and 14, respectively, and were compiled from drillers' records and field data. Pumping tests were performed on about 200 wells, continuous water-level records were obtained for 7 wells, and periodic water-level measurements were made on a network of 250 wells. Samples of water from more than 100 sites were analyzed for chemical constituents, and samples from more than 50 sites were analyzed for coliform bacteria. Surface and borehole geophysical data, aerial photographs, and imagery, along with private industrial and public reports and records, were also helpful to the study.

ACKNOWLEDGEMENTS

The interest and cooperation of the people residing in the Cumberland Valley was essential to the acquisition of field data for this study. We gratefully acknowledge the help of all those people who kindly allowed us access to their land and wells. The Cumberland Valley School District and the Summerdale Agricultural Laboratory, particularly their buildings and grounds staffs, were most helpful and cooperative during the long-term pumping tests on their well fields. The cooperation and help of Mr. Harold Kauffman and his staff at Shippensburg State College in several phases of our work was greatly appreciated. Our thanks are also extended to Mr.

Table 1. *Water Use from Public Supply Systems*

Name of system	Source(s) of supply: Well	Source(s) of supply: Spring	Source(s) of supply: Stream	Source(s) of supply: Reservoir	Amount used (Mgal/d) 1960	Amount used (Mgal/d) 1975	Population served[1] 1975
Carlisle Barracks		1			- - -	0.91	2,500
Carlisle Borough Authority			1	1	2.41	4.24	22,880
Carlisle Suburban Authority	2				- - -	.15	2,200
Center Square Water Company	1				.05	.03	610
Forge Road Acres Water Company	1				- - -	.01	210
Grantham Water Company		1			.03	.17	1,590
Huckleberry Land Association		1			- - -	.02	450
Mechanicsburg Water Company	1	1	1		.96	1.68	14,330
Mount Holly Springs Borough Authority	1		2		- - -	.3	2,400
Newville Borough Authority		1			.09	.14	2,010
Riverton Water Company			2		4.98	9.38	74,315
Shippensburg Borough Authority		1	3	3	2.0	2.28	11,900
South Middleton Township Authority	2				.16	.46	2,490
Summerdale Water Company	2				- - -	.03	650
White Hill Correctional Institute	1		1		- - -	.24	1,200
White Rock Water Company		1			- - -	.001	120
Williams Grove Park Company		1			- - -	.003	500

[1] Interpolated from 1969 data and 1980 projections.

Data source: Files of Pennsylvania Department of Environmental Resources, 1975.

Rodger Hoke, Mr. Wilbur Bucher, and Mr. William Otto for allowing test drilling on their property. We also thank the drillers who provided information about wells in the area, especially Moody and Associates, and Eldon E. Funk for his practical advice and assistance in the test-drilling program.

This study owes much to Walter Wetterhall, who spent several years collecting both hydrologic and geologic data prior to his retirement. Walt also lent his knowledge and experience to the planning of some phases of the hydrologic studies.

GEOHYDROLOGY

GEOLOGIC SETTING [1]

Steep forested ridges of resistant quartzite in South Mountain and quartzitic sandstone in Blue Mountain (Figure 1) bound the Cumberland Valley on the southeast and northwest, respectively. The principal rock types that underlie the valley are shale on the northwest side and limestone on the southeast. A thick layer of colluvium overlies the oldest rocks along the flank of South Mountain southward into Maryland.

Two sequences of consolidated sedimentary rock, the Cumberland Valley and the Lebanon Valley sequences, were mapped in the Cumberland Valley (Figure 2). Most of the valley is underlain by the Cumberland Valley sequence. The extreme southeast corner is underlain by the upper part of the Lebanon Valley sequence. Both sequences are tilted to the northwest so that the eroded edges of successively younger rocks are exposed from southeast to northwest (Plate 1).

The Cumberland Valley sequence forms the northwest limb of a regional anticline that has its axis in South Mountain (Figure 1). Rocks of this sequence are deformed into asymmetric folds and steeply dipping faults that are subparallel to the valley trend. The Lebanon Valley sequence is more intensely deformed by several periods of movements of the Earth's crust.

Figure 3 shows the rock units, their sequential relations, and the equivalence between sequences. Limestone is the dominant rock type in both sequences. The lower three limestone units contain significant amounts of dolomite, siltstone, shale, and some sandstone. The uppermost unit in the Cumberland Valley sequence is a thick shale (autochthonous, or normal, Martinsburg Formation) that is exposed over a large area (Plate 1). Interlayered with the normal Martinsburg are slices of rock composed of shale and small amounts of limestone, siltstone, and sandstone, collectively called the allochthonous, or transported, Martinsburg. These rocks occur east of Carlisle in the Cumberland Valley sequence (Figure 2) and compose most of the Martinsburg in the Lebanon Valley sequence.

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[1] The stratigraphic nomenclature used in this report is that of the Pennsylvania Geological Survey and does not necessarily conform to the usage of the U.S. Geological Survey.

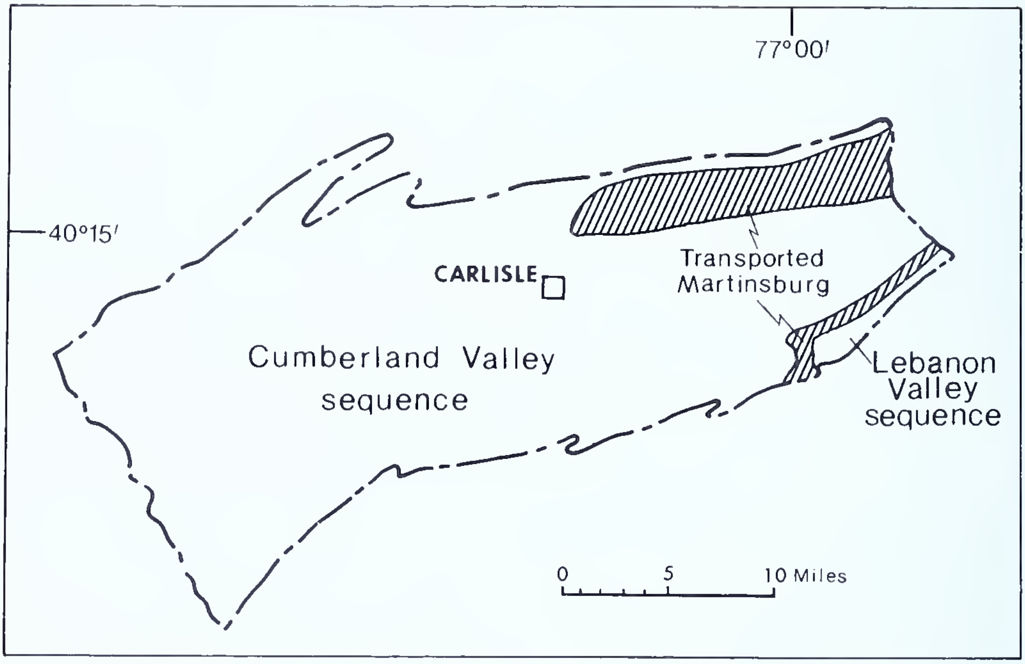

Figure 2. Distribution of sedimentary rocks in the Cumberland Valley.

Sediments that formed these rocks were deposited in different parts of a former sea at approximately the same time. Major movements of the Earth's crust, first involving the transported Martinsburg and then the Lebanon Valley sequence, placed them in their present relationship to the Cumberland Valley sequence. A more thorough discussion of the geology is given in the Appendix.

HYDROLOGIC SYSTEM

Water enters the northern Cumberland Valley as precipitation and streamflow, and leaves as water vapor in the atmosphere or as overland runoff, or percolates underground, ultimately reaching streams and the Susquehanna River. Some is discharged to the Susquehanna by springs in the river bottom, but most enters by either Conodoguinet or Yellow Breeches Creek. Both streams flow eastward, parallel to the structural grain of the valley (Plate 1). Conodoguinet Creek drains most of the Cumberland Valley north and west of Yellow Breeches Creek. The Yellow Breeches drains about a third of the Cumberland Valley east of Boiling Springs, those areas nearest South Mountain as far west as Walnut Bottom, and the uplands of South Mountain. The hydrologic system is composed of these dynamically related parts, and the quantities of water that move through each part place natural limits on the development and management of the water resources. Neither the groundwater nor surface-water parts of the system can be developed without affecting each other, because stresses placed on one part of the system affect the other parts.

SYSTEM	SERIES		CUMBERLANO VALLEY SEQUENCE UNITS	THICKNESS (IN FEET)	LEBANON VALLEY SEQUENCE UNITS	THICKNESS (IN FEET)
Quaternory			Colluvium	0-450		
Ordavician	Upper Ordovician		Martinsburg Formation	Unknown	Martinsburg Formation	Unknown
			Transported Martinsburg (?)	Unknown	Transported Martinsburg (?)	Unknown
	Middle Ordovician		Chambersburg Formation	650	Myerstown Formation	Unknown
			St Paul Group	600-900		
		Beekmantown Graup	Pinesburg Station Formation	175-300		
	? Lower Ordovician	Beekmantown Graup	Rockdale Run Formation	2,000-2,500	Epler Formation	Unknown
			Stonehenge Formation	500		
			Stoufferstown Formation	0-200		
Cambrian	Upper Cambrian	Conacacheague Group	Shadygrove Formotion	800-1,000		
			Zullinger Formation	3,500		
	Middle Cambrian		Elbrook Formation	3,500		
	Lower Cambrian		Waynesboro Formation	1,000-1,500		
			Tomstown Formation	1,000-2,000		

Figure 3. Stratigraphic relationships and thicknesses of rock units in the Cumberland Valley.

Water Budgets

The quantitative expression of the hydrologic system is a water budget, which balances the input and output of the system and can be stated as follows:

$$P = R + ET \pm U$$

where

P = precipitation,

R = streamflow,

ET = evaporation and transpiration, and

U = groundwater transfers across basin boundaries.

An average annual water budget was determined for each of the two stream basins. Precipitation (P) was calculated from the records of six U. S.

Weather Bureau stations (U. S. Environmental Data Service, 1931–74). The long-term, average annual precipitation is 40.40 inches for the Conodoguinet basin and 39.95 inches for the Yellow Breeches basin.

Streamflow (R) was obtained from the records of the U. S. Geological Survey for gaging stations (U. S. Geological Survey, 1968–74) on the Conodoguinet, near Hogestown, and on the Yellow Breeches, near Camp Hill (Plate 1). In order that precipitation and streamflow data be continuous and for comparable periods of time, only records for the 7 water years from 1968 through 1974 were used. Precipitation for this period was 4.5 and 8 percent above average in the Conodoguinet and Yellow Breeches basins, respectively. The 7-year period began with 2 years of precipitation below average, followed by 2 years above average, and then 2 years far above average. That for 1974 was about average. Tropical storm Agnes in June 1972 contributed 10 to 15 inches of precipitation to the system. For the next 4 months precipitation was well below average.

An amount equal to about 8 percent of the average discharge at the gaging station on Yellow Breeches Creek is diverted naturally from the basin through Big Spring (Sp–22) into Conodoguinet Creek. The amount diverted (U) was calculated by averaging 10 measurements of discharge from Big Spring at different times of the year, between 1944 and 1971; about 10 percent of the flow was assumed to be derived from local recharge.

Evaporation and transpiration (ET) were determined by difference in the budget equation. Changes in soil-moisture storage may be large between the growing and nongrowing seasons but are unlikely to be more than a few percent of the annual budget and less for longer periods. Changes in groundwater storage are normally large from season to season but negligible when averaged over periods of several years. No significant amounts of water are known to be transferred by man across basin boundaries. Some diversions of water by water companies and industry do occur in the lower parts of the basin, but these amount to less than 1 percent of average streamflow.

Table 2 compares the water budgets of the two major basins. Differences between the budgets are attributable to differences in basin characteristics such as geology, land use, temperature, and topography. For example, the Conodoguinet Creek basin drains about 46 percent carbonate rock and 54 percent noncarbonate rock, mostly Martinsburg shale. About 34 percent of the Yellow Breeches Creek basin drains carbonate rock and colluvium overlying it and 66 percent noncarbonate rocks, mostly quartzite and metamorphic rocks. The average altitude of the Conodoguinet basin is about 700 feet, compared to 800 feet for the Yellow Breeches basin. A study in Monroe County (Carswell and Lloyd, 1979) showed that a 100-foot increase in altitude can change the amount of precipitation lost to evapotranspiration by 2 to 3 percent. Most of the Conodoguinet basin is farmland, whereas a large part of the Yellow Breeches basin is forested.

Table 2. Water Budgets for Major Stream Basins

Water year	Precipitation P (inches)	=	Streamflow R (inches)	–	Interbasin flow U (inches)	+	Water losses ET (inches)
CONODOGUINET CREEK							
1968	35.86	=	13.55	–	0.55	+	22.86
1969	33.43	=	11.13	–	.44	+	22.74
1970	44.24	=	19.62	–	.78	+	25.40
1971	42.49	=	20.49	–	.77	+	22.77
1972	51.07	=	30.25	–	1.15	+	21.97
1973	49.48	=	25.38	–	.92	+	25.02
1974	39.01	=	18.61	–	.78	+	21.18
7-year average	42.23	=	19.86	–	.77	+	23.13
Percent of total	100	=	47	–	2	+	55
YELLOW BREECHES CREEK							
1968	37.01	=	15.03	+	1.20	+	20.78
1969	33.56	=	12.10	+	.97	+	20.49
1970	46.47	=	21.20	+	1.70	+	23.57
1971	43.11	=	21.05	+	1.68	+	20.38
1972	52.02	=	31.49	+	2.52	+	18.01
1973	48.73	=	24.99	+	2.00	+	21.74
1974	41.66	=	21.16	+	1.69	+	18.81
7-year average	43.22	=	21.00	+	1.68	+	20.54
Percent of total	100	=	48	+	4	+	48

About half of the precipitation is consumed by ET and cannot be recovered for other uses. Comparison of annual data in either basin indicates that ET remains fairly constant even when precipitation and streamflow vary widely. ET was higher than average during water years 1970 and 1973 and lower than average during water years 1972 and 1974. With the exception of water year 1972, years of above average ET had above normal precipitation between May and September, and, conversely, years of below average ET had below normal precipitation. Precipitation from tropical storm Agnes in June 1972 made the summer of 1972 an above normal precipitation period; however, each of the 3 months following the storm had well below normal precipitation, and this is the more significant factor.

In summary, an average of 0.95 (Mgal/d)/mi^2 (million gallons per day per square mile) of water is available for use in the Cumberland Valley without reuse. Most of this water is groundwater discharge to streams.

Groundwater Contributions to Streamflow

Conodoguinet Creek

Based on an analysis of streamflow records for the Conodoguinet Creek basin during 1968–74, groundwater discharge to the stream is about two thirds the total streamflow. During this period, groundwater discharge (or

base flow) averaged 202,000 gal/min (gallons per minute) and ranged from 112,000 to 267,000 gal/min or from 57 to 75 percent of the total flow. Separate estimates of groundwater discharge from the shale and carbonate terranes are given in Table 3 and show the effects of geology on the hydrologic characteristics of the basin. Groundwater discharge from the shale averaged only 55 percent of the streamflow from the shale terrane and ranged from 39 to 63 percent. In contrast, groundwater discharge from the carbonate rocks averaged 80 percent and ranged from 72 to 87 percent of the streamflow from the carbonate rocks. Stated differently, streamflow in the basin during and up to 3 days after rainfall is derived largely from overland runoff from the shale, but thereafter streamflow is maintained increasingly by discharge from the carbonate rocks. The yield of the shale averages 0.59 $(Mgal/d)/mi^2$ and that of the carbonates averages 0.86 $(Mgal/d)/mi^2$.

Yellow Breeches Creek

Estimates of groundwater discharge from the Yellow Breeches Creek basin are shown in Table 4 for the same years as the Conodoguinet Creek basin. Groundwater discharge averaged 80 percent and ranged from 70 to 87 percent of annual flow. These proportions are significantly larger than for the Conodoguinet and reflect the capacity of the colluvium in the Yellow Breeches basin to store water. Slow release of water to the limestone aquifer sustains fairly constant discharges from the many springs. The larger springs are at Huntsdale and Boiling Springs and account for about 20 percent of the annual discharge of the Yellow Breeches. As a result, flow is more constant than in the Conodoguinet. For example, during periods of low flow (that flow exceeded 90 percent of the time), the discharge per unit area of the Conodoguinet basin is less than half the discharge of the Yellow Breeches. Conversely, during peak flows (those exceeded only 2 percent of the time), discharges are 25 percent lower in the Yellow Breeches. Therefore, storage of water in the colluvium is a significant factor affecting both water supply and flood-control planning.

Specific Yield of Carbonate Rocks in the Conodoguinet Creek Basin

Specific yield is an estimate of the average volume of openings available for storage of water in an aquifer. For the zone of fluctuation of groundwater levels in the carbonate rocks of the Conodoguinet Creek basin, an average specific yield of 0.05, or 5 percent, was calculated for four periods of 6 to 16 days duration. Values for single periods ranged from 0.04 to 0.06. All periods began at least 3 days after rain ceased, when no snow was on the ground and evaporation and transpiration were negligible. Figure 4 shows the hydrograph of two of the wells and one period used in calculating the specific yield.

Table 3. *Hydrologic Characteristics of the Conodoguinet Creek Basin*

	Mean discharge (thousand gal/min)			=	Direct runoff (thousand gal/min)			+	Base flow (thousand gal/min)			
Water year	Carbonate terrane	Shale terrane	All terrane		Carbonate terrane	Shale terrane	All terrane		Carbonate terrane	Shale terrane	All terrane	Percent base flow of total discharge
1968			210	=			76	+			134	64
1969			173	=			61	+			112	65
1970	139			=	33			+	106			76
		166		=		73		+		93		56
			305	=			106	+			199	65
1971	145			=	20			+	125			86
		173		=		73		+		100		58
			318	=			93	+			225	71
1972	213			=	47			+	166			78
		256		=		155		+		101		39
			469	=			202	+			267	57
1973	179			=	49			+	130			72
		215		=		79		+		136		63
			394	=			128	+			266	68
1974	131			=	17			+	114			87
		158		=		57		+		101		63
			289	=			74	+			215	75
5-year average	161			=	33			+	128			80
Do.		194		=		88		+		106		55
7-year average			308	=			106	+			202	66

Table 4. *Hydrologic Characteristics of the Yellow Breeches Creek Basin*

Water year	Mean discharge (thousand gal/min)	=	Direct runoff (thousand gal/min)	+	Base flow (thousand gal/min)	Base flow of discharge (percent)
1968	107	=	18	+	89	83
1969	87	=	13	+	74	85
1970	151	=	34	+	117	77
1971	150	=	22	+	128	85
1972	224	=	68	+	156	70
1973	178	=	30	+	148	83
1974	151	=	20	+	131	87
Average	150	=	30	+	120	80

Storage below the zone of water-level fluctuation is much lower because solution is less active, and probably is less than the 2 percent calculated for the total aquifer thickness in Lehigh County by Wood and others (1972, p. 171).

The specific yield can be used in calculating the average effects of groundwater development on water levels and to estimate the rise in groundwater levels from recharge.

HYDROLOGIC SYSTEM IN THE CARBONATE ROCKS

Water-level maps, when used with geologic, chemical, and other hydrologic data, provide both qualitative and semiquantitative information about the groundwater system. Water levels measured in about 250 wells in the carbonate rocks during the second week of November 1972 are shown on Plate 1. Contours show a groundwater surface that slopes generally northward. A groundwater divide extends eastward from Hays Grove to Camp Hill and separates the drainage areas of Conodoguinet and Yellow Breeches Creeks. Most of the carbonate-rock aquifer drains northward to Conodoguinet Creek, as the divide occurs just north of Yellow Breeches Creek in much of the area and the creek flows near the south edge of the carbonate terrane.

Water levels in many wells on both sides of the groundwater divide north of Yellow Breeches Creek showed no decline from spring to fall 1972 (Plate 2), and some were higher in the fall. Part of this effect is due to excessive local recharge from tropical storm Agnes, which raised water levels far above those measured in March 1972. A comparison of November water levels between 1971 and 1972 shows that much of the effect of this storm was dissipated by fall. Water levels change little during any year in the divide area, because recharge of the local aquifer occurs constantly from the flanks of South Mountain.

The greatest seasonal declines in water levels occur on the north side of the carbonate valley within a half mile to a mile of Conodoguinet Creek

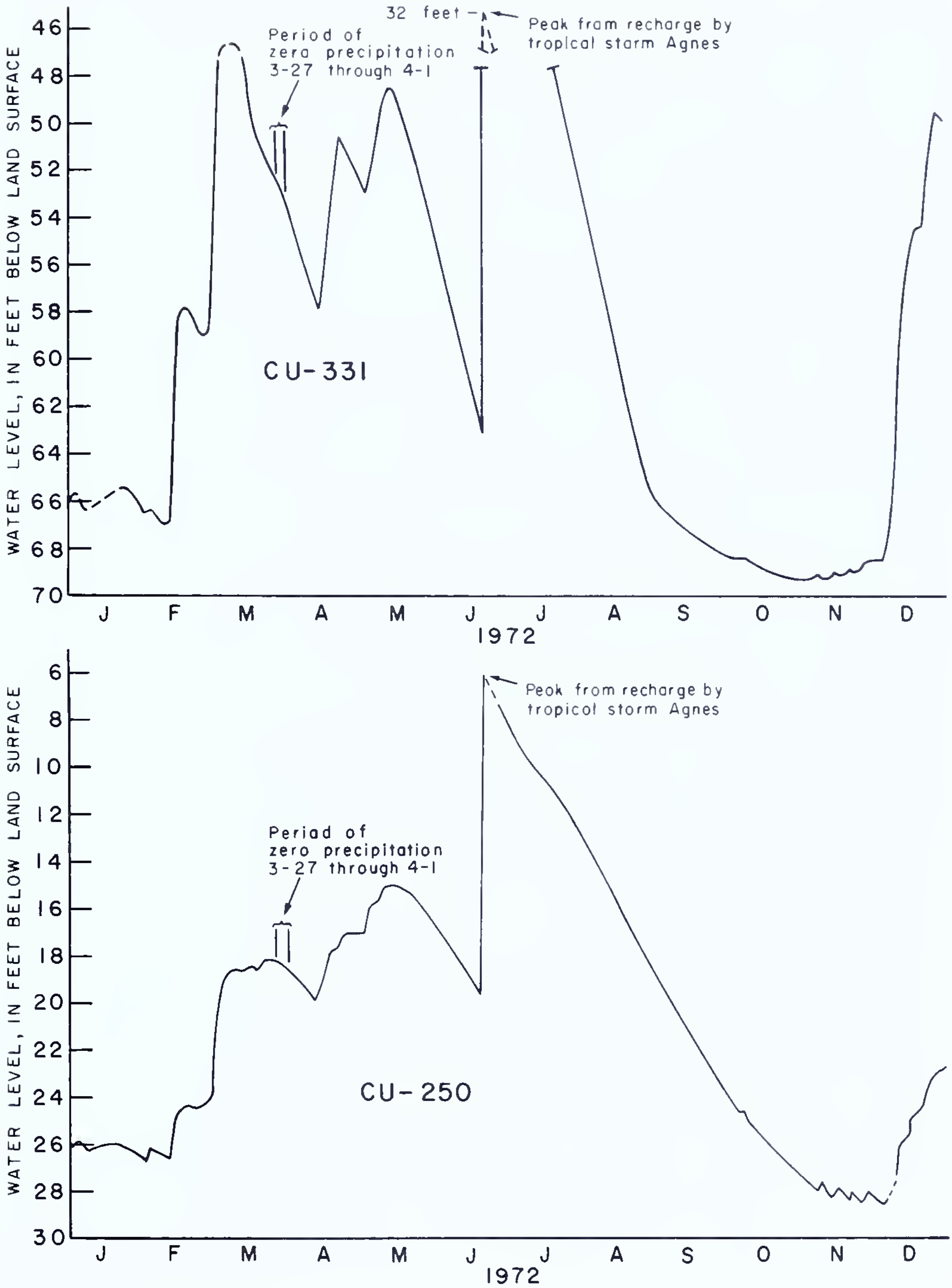

Figure 4. Hydrographs of wells in the Conodoguinet Creek basin, showing one period of specific-yield calculation and the effects of tropical storm Agnes.

(Plate 1) between streams sustained by mid-valley springs. The north side does not receive sufficient recharge locally or from the south side of the carbonate valley to prevent water-level declines through the summer months due to natural discharge.

Spacing of contour lines on the groundwater-surface map indicates the relative ability of the rocks to transmit water. Wide spacing indicates a greater ability to transmit water than narrow spacing. The carbonate aquifer north of about latitude 40°08'N has about twice the ability to transmit water than the aquifer south of this latitude, based on average gradients of the water-level surface.

Springs, as well as being major potential sources of water, provide considerable information about the hydrologic system. Of the 10 largest springs in Pennsylvania, three are in Cumberland County. Each has a median yield in excess of 10,000 gal/min. Table 14 provides information on most of the larger springs in the valley, including discharge and field water-quality data.

Geologic Controls on Groundwater Availability and Movement

The major geologic features that influence the hydrologic system in the carbonate rocks are:

1. Lithologic differences in the carbonate-rock sequence.
2. The colluvium that overlies both the lower units of the carbonate-rock sequence and the ridge-forming quartzite that forms the southern border.
3. Shale that borders the carbonate rocks on the north.
4. The north-south-oriented diabase dike (Stony Ridge) that extends across the valley through the town of Boiling Springs.
5. Faults, folds, and the attitude of bedding.

Lithologic Differences

The formation of a groundwater divide just north of Yellow Breeches Creek and the steeper gradient on the water surface in the southern part of the carbonate valley are caused by lithology. The lower part of the carbonate sequence, especially the Elbrook and Waynesboro Formations, contains large amounts of shale, calcareous shale, argillaceous limestone and dolomite, siltstone, and calcareous sandstone. Enlargement of openings in these rocks by solution is counterbalanced by filling with residual clay, silt, and sand as the carbonate material is dissolved. Therefore, flow in these rocks is retarded more than in the carbonate rocks of lower insoluble-residue content to the north.

Quartzite and Colluvium

The eroded ridges bordering the Cumberland Valley on the south and standing 600 to 900 feet above the adjacent carbonate valley are made up of quartzite rocks and are collectively called South Mountain. Water moving from South Mountain toward the valley flows through or across a thick wedge of colluvium that mantles the ridge slopes and overlies the Tomstown

Formation and most of the Waynesboro Formation. Much of the water filters through the colluvium into the carbonate rock. Because the water is highly charged with carbon dioxide and is low in dissolved solids, it dissolves the carbonate rocks rapidly and produces large solution channels and a deeply weathered residuum. Colluvium and residuum are moved into the cavernous openings by gravity and hydraulic action, partly or wholly filling them, especially the shallower ones. Greater solution of the Tomstown has lowered its surface below that of the adjacent carbonate rocks to the north, thereby helping create the valley in which the Yellow Breeches Creek flows.

Much of the water that enters bedrock solution openings through the colluvium moves under Yellow Breeches Creek and is discharged by several large springs of moderately variable flow and many small perennial springs. Boiling Springs (Sp–6 and –7), Big Spring (Sp–22), and Baker Spring (Sp–31) have average discharges of 16.5 Mgal/d, 16.8 Mgal/d, and 3.2 Mgal/d, respectively. Drainage areas up-gradient from these springs are too small to sustain their discharges based on an average basin-wide groundwater discharge of 0.81 (Mgal/d)/mi^2.

Big Spring diverts 5 to 10 percent of the average flow of the Yellow Breeches to Conodoguinet Creek. The magnitude of its flow relative to its drainage area is the primary indication of the diversion. Headwater tributaries of Yellow Breeches Creek, directly south of Big Spring, lose water as they flow across the colluvium. Yellow Breeches Creek is usually dry for 1-1/2 miles downstream from Brookside during summer and fall. The temperature of water from Big Spring fluctuates only 0.4°C annually, and seasonal changes lag air-temperature changes by about 3 months (Figure 5). Furthermore, the specific conductance (an electrical measure of the amount of minerals in solution) of water from the spring is about two thirds that of water from nearby wells. Increases in specific conductance and hardness show (Figure 5) no seasonal lag and are caused by mixing with water from local recharge. Turbidity of the water for several days following major storms also indicates some local recharge to the spring.

A natural conduit system along a projection into the valley of the north-south-oriented fault, directly south of Big Spring in South Mountain, probably is the major conveyor of water to the spring. Although the fault does not extend into the carbonate rocks, shearing probably produced a zone of weakness that developed into a conduit system by the action of water.

High-yield wells can be developed in the conduit system. However, production from such wells could reduce the flow of Big Spring and the supply of water to the Big Spring Fish Hatchery.

Boiling Springs (Sp–6 and –7) and Baker Spring (Sp–31) flow from the south flank of the divide north of Yellow Breeches Creek and form strong boils that indicate significantly greater heads than the static elevation head. The configuration of water-level contours is not altered by the discharges,

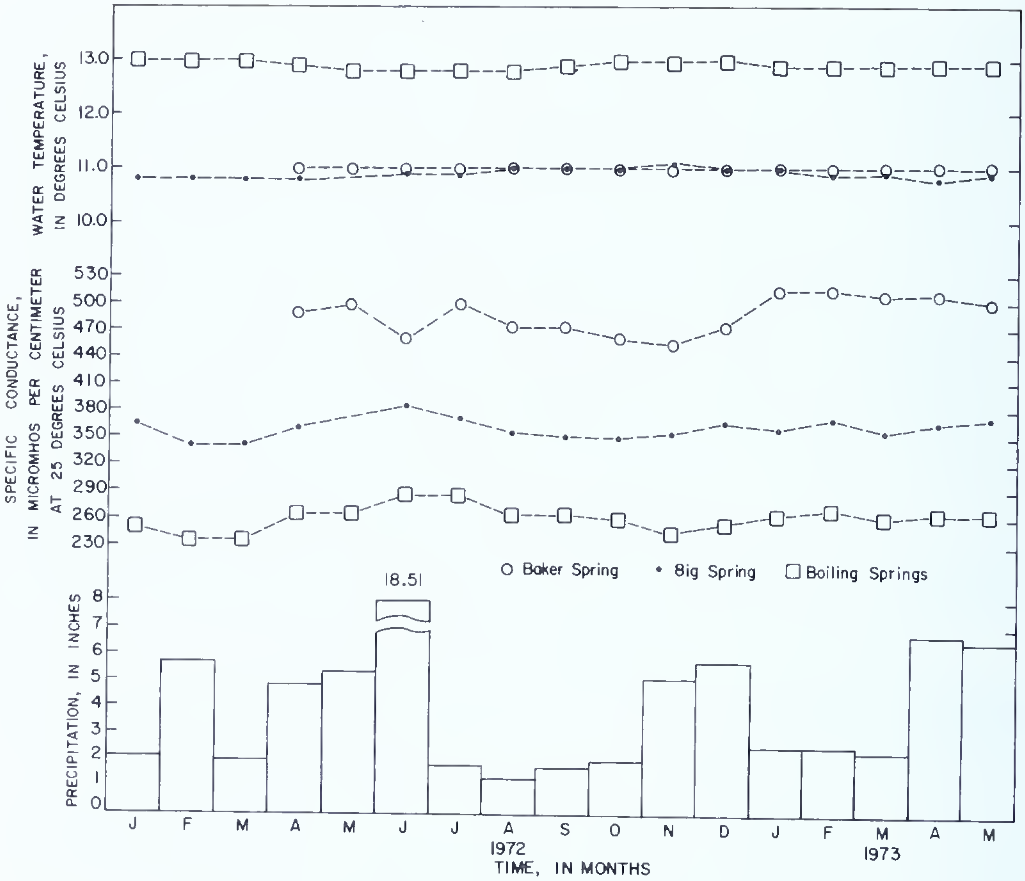

Figure 5. Monthly temperature and specific-conductance measurements of water from Boiling Springs (Sp–6), Big Spring (Sp–22), and Baker Spring (Sp–31), and of precipitation at Carlisle.

indicating that the discharges do not deplete the local groundwater system. Water temperature fluctuates only 0.2°C annually in Boiling Springs (Figure 5) and lags air-temperature changes by 4 to 6 months. The temperature of water from Baker Spring is a constant 11°C, indicating that it is unaffected by seasonal changes in air temperature. The specific conductances of water from Boiling Springs and Baker Spring are 50 and 85 percent, respectively, of the usual value of groundwater in carbonate rock. Fluctuations in specific conductance result from flushing of the local soil horizon.

In summary, the location of several large springs, and their discharge, temperature, and gross chemical character reveal the controlling effects of the quartzite and colluvium on the groundwater system. More importantly, they suggest areas where large quantities of groundwater can be developed.

Shale

Shale of the Martinsburg Formation generally limits the northward flow of groundwater from the carbonates. Although the discharge from springs

in the carbonates may flow across the shale for short distances into the Conodoguinet, in most places the Conodoguinet flows on shale bedrock near the contact of shale with the carbonates. Some discharge from the carbonate aquifer goes directly into the Conodoguinet where the stream is in contact with it.

Diabase Dike and Faults

The diabase dike extending northward across the limestone valley from Boiling Springs acts as a subsurface dam. Although only 30 to 50 feet thick, it is impermeable and relatively insoluble, so that weathering is probably effective only to very shallow depths. Hydrologic relationships on either side of the dike illustrate its barrier effect.

Damming by the dike clearly shows on the groundwater-level map (Plate 1). Water levels are about 50 feet higher on the western side of the dike than on the eastern side. Streamflow measurements show the combined effects of the dike and faults on the groundwater and surface-water flow systems. A series of small perennial springs occur just west of the dike and flow eastward across it onto the carbonate terrane. During the summer and fall the tributaries to Hogestown Run, fed by the springs, lose water to the subsurface (Figure 6) and are completely dry half a mile after crossing the dike. The main stem of Hogestown Run gradually loses water, as shown by succeeding downstream measurements, but continues to flow for about 2 miles. Hogestown Run and one of its tributaries become dry where they cross faults. Streamflow begins again where the main stem recrosses the fault, suggesting that the fault serves as a subsurface diversion channel.

Mount Rock Spring Creek has a measured dry-weather loss of about one third its flow to the groundwater system in the vicinity of a fault near Kernsville. Gains and losses of streamflow that can be related to geologic features indicate places where it is possible to develop large supplies of groundwater. The fault at Kernsville is an example. However, a greater potential exists for bacteria and other pollutants to contaminate these supplies because natural filtration is inadequate in large openings. Water from wells northeast of the fault near Kernsville has high specific conductance (Plate 3), and many people report bacterial contamination of their wells.

Folds, Faults, and Bedding Attitude

Two types of geologic controls seem to influence the locations of the three largest mid-valley springs in the western half of the carbonate aquifer. Two of the springs occur near axes of folds, Big Spring (Sp–22) on an anticline and Mount Rock Spring (Sp–17) on a syncline. A fault very near Sp–17 may also have influenced the location of this spring. All three springs are associated with the Stoufferstown Formation, the uppermost of the lower impure carbonate units: Sp–17 and –22 flow from rocks stratigraphically about 100 feet below the base of the formation; and Alexander Spring

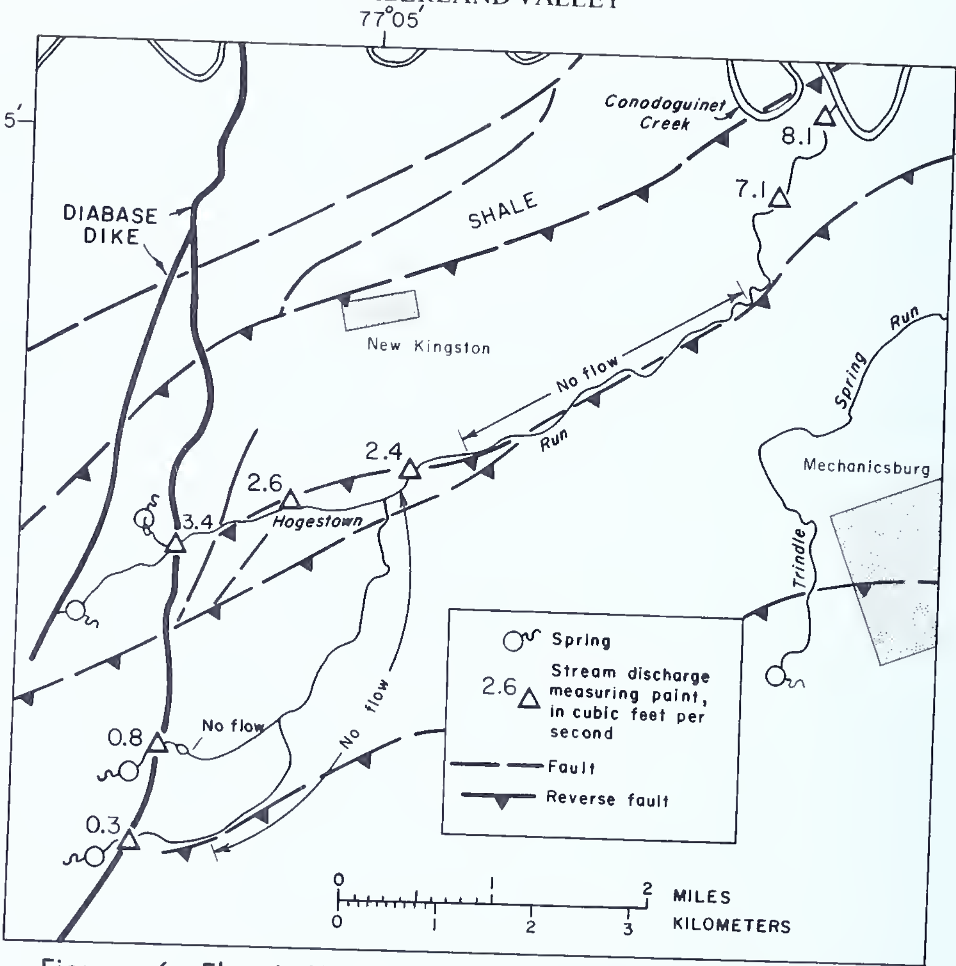

Figure 6. Flow in Hogestown Run on September 21, 1972.

(Sp–16) flows from rocks about 100 feet above the top of the formation. Silver Spring (Sp–4) and Trindle Spring (Sp–5) near Mechanicsburg also occur on the axes of anticlines, but local structure and variations in lithology place them stratigraphically between 300 and 1,000 feet below the base of the Stoufferstown Formation.

A northeast orientation of troughs on the groundwater-surface contour map (Plate 1), especially in the northern half of the carbonate aquifer, suggests that the generally northeast strike of bedding tends to divert flow in this direction.

WATER-YIELDING PROPERTIES OF THE ROCK UNITS

Rocks that can supply usable quantities of water to wells and springs are called aquifers. Openings in unconsolidated-rock aquifers, such as the colluvium adjacent to South Mountain, occur primarily as voids between packed grains. However, most of the openings in rocks of the Cumberland Valley occur as separations along breaks in the rock formations; some for-

mations tend to develop more openings or breaks than others, and are therefore considered to be better aquifers. The breaks in the formations may be bedding surfaces or fault, joint, and cleavage surfaces, produced by physical stress. Any of these types of openings may be enlarged by chemical action. The size, spacing, distribution, and extent of interconnection of these openings determine the ability of the aquifer to store and transmit water and, therefore, the ability of wells to yield water.

A well must intercept at least one yielding zone to obtain any water. Data on the distribution of yielding zones intercepted by many wells are useful in assessing the yielding capability of aquifers. Table 5 summarizes information from drillers' well-completion reports on yielding zones together with other well-completion statistics. Evaluation of these data is useful in making pre-drilling estimates of relative construction characteristics. For example, a comparison between data from all Ordovician and Cambrian carbonate formations indicates that wells in the latter are deeper, require more than twice the amount of casing, have deeper yielding zones, and have deeper water levels. In practical terms, wells in the Cambrian units will cost more to construct and require greater pumping lifts to obtain the same amount of water as wells in Ordovician carbonates. However, because the wells are cased deeper and the water levels and yield zones are deeper, the water is less susceptible to contamination.

The well data are also helpful in making decisions during the drilling of a well. For wells being drilled for high yields, the depth data on yielding zones in Table 5 are valuable both for planning optimum well depth and for making decisions during drilling on whether to deepen the well in search of additional water. For example, the depth of a well in the Rockdale Run Formation might be planned for 150 feet to take advantage of the depth of maximum development of yield zones (0 to 50 feet) and to penetrate more than half the zones (median 51 to 100 feet). If the quantities of water obtained to that depth were only marginally adequate, it might be practical to deepen the well even to 500 feet, as additional zones were penetrated to this depth.

Wells intended for single-dwelling use need to be drilled to about 200 feet, if adequate amounts of water have not been developed at shallower depths. If some water has been obtained, deeper drilling will provide a storage reserve in the borehole, even if no additional yielding zones are penetrated. However, dry holes that have encountered only fresh rock to 200 feet are unlikely to encounter water at greater depths because most yield zones are at shallower depths.

Specific Capacity

Rocks in the Cumberland Valley differ greatly in their ability to supply water to wells. Pumping tests of 1-hour duration on 188 wells were used to evaluate the water-yielding capability of the various units. The results of

Table 5. *Summary of Well Construction Statistics*

Rock unit	Well depth (feet)			Casing depth (feet)			Yield zones[1]						
										Depth ranges (feet)		Most zones[2]	
	Number of wells	Median	Maximum	Number of wells	Median	Maxi-mum	Number of wells	Number of yield zones	Depth of deepest well (feet)	Median zone	Deepest zone	Depth range (feet)	Total or average number
Colluvium	23	88	265	21	83	247	17	3	265	51-100	201-250	---[3]	---[3]
Martinsburg Fm. — transported	30	134	500	15	30	200	13	24	398	51-100	351-400	0-200	[5]2
Martinsburg Fm. — normal	48	88	635	20	30	112	95	166	635	51-100	301-350	51-100	3
Ordovician carbonate formations	204	129	730	36	30	200	90	164	600	51-100	551-600	0-50	5
Chambersburg Fm.	22	178	730	18	38	153	10	22	530	151-200	501-550	0-50	3
St. Paul Group	39	178	600	19	40	143	14	31	600	101-150	551-600	51-100	2
Pinesburg Station Fm.	[4]5	128	285	[4]5	42	124	[4]1	3	275	151-200		---[4]	---[4]
Rockdale Run Fm.	121	82	520	82	26	200	55	91	520	51-100	451-500	0-50	7
Stonehenge Fm.	10	109	265	8	26	130	6	10	240	51-100	201-250	0-50	5
Stoufferstown Fm.	[4]6	239	400	[4]4	54	112	[4]4	7	400	151-200	351-400	---[4]	---[4]
Cambrian carbonate formations	188	150	1000	111	77	450	64	113	460	101-150	451-500	51-200	[5]2
Shadygrove Fm.	28	165	600	17	51	94	9	16	460	101-150	451-500	151-200	2
Zullinger Fm.	52	191	1000	27	80	203	16	28	423	151-200	401-450	0-450	[5]1
Elbrook Fm.	55	127	450	26	55	210	13	27	367	101-150	351-400	101-150	3
Waynesboro Fm.	22	86	516	13	47	197	7	10	160	51-100	101-150	0-150	[5]4
Tomstown Fm.	31	160	600	28	101	450	19	38	500	151-200	451-500	51-200	[5]4

[1] Grouped in 50-foot increments.
[2] For each 100 feet of hole sampled.
[3] Not applicable.
[4] Insufficient data.
[5] Evenly distributed through indicated depth ranges.

these tests are shown in Table 13 as the specific capacity of the well. Figure 7 illustrates how a test is done and how the specific capacity is calculated. Specific-capacity data are used to compare the yields of wells grouped according to rock formation as well as other criteria that are related to the yield. For example, a greater susceptibility to solution by water produces a much higher yielding aquifer in carbonate rock than in other kinds of consolidated rock. The median specific capacity of 3 (gal/min)/ft (gallons per minute per foot) for wells in the carbonate rocks is more than five times the median of 0.55 (gal/min)/ft for wells in the Martinsburg Formation. Furthermore, about one third of the wells in the carbonate rocks have specific capacities greater than the maximum of wells in the Martinsburg.

Sustained Yield

Specific-capacity data also can be used to estimate a sustained yield—a quantity more directly useful in selecting areas for development of high-production wells. The sustained yield is defined as the amount of water, in gallons per minute, that can be obtained continuously from a well for 24 hours. It is calculated by multiplying the median specific capacity obtained after 24 hours of pumping by the available drawdown. The specific capacity for 24 hours was calculated by reducing the median specific capacity obtained for 1 hour of pumping by the average decline observed in wells pumped for 24 hours. An average decline of 25 percent and 35 percent was observed, in the field, for carbonate and shale wells, respectively. The available drawdown is the difference between the median depth to water, given in Table 6, and the midpoint of the depth range in which the median-yield zone occurs, given in Table 5.

Table 6 summarizes the water-yielding capabilities of the rocks. The last column of the table shows the median reported yields from drillers' well-completion reports. With one exception, these yields are below, and many are far below, the calculated sustained yields.

No difference exists between the specific capacities of 109 domestic and 53 nondomestic (public-supply, industrial, and other high-yield uses) wells in carbonate rocks. However, the specific capacities of nondomestic wells would have been higher if the wells had been pumped at the low rates of domestic wells because drawdowns would have been less. The nondomestic wells are better because they are located almost exclusively on the best sites. Domestic wells are located almost exclusively for economy and convenience.

Geologic Character and Yields of the Rock Units

In the discussions of the individual rock units that follow, nomenclature and descriptions are those of Root (1968, 1971), based on work in Franklin County, modified to account for differences present in Cumberland County.

A = Depth to static-water level in feet
B = Depth to pumping-water level in feet
Drawdown = B-A
C = Maximum possible drawdown
Q = Yield in gallons per minute

$$\text{Specific capacity} = \frac{\text{Yield}}{\text{Drawdown}} = \frac{Q}{B\text{-}A}$$

For example: water stands 62 feet below the surface before a well is pumped (A = 62 feet). The pump is run for an hour and is measured by filling a 55-gallon drum in 10 minutes (Q = $\frac{55}{10}$ = 5.5 gallons per minute). The water level is then found to be 73 feet below the surface of the ground (B = 73 feet). The drawdown is then 73 – 62 = 11 feet and the specific capacity is $\frac{5.5}{11}$ = 0.5 gallon per minute per foot of drawdown. If the well is 100 feet deep, the maximum possible drawdown (C) is 100 – 62 = 38 feet. Therefore, the maximum rate at which the well could ever be pumped is 0.5 $\frac{\text{gpm}}{\text{feet}}$ X 38 feet = 19 gallons per minute.

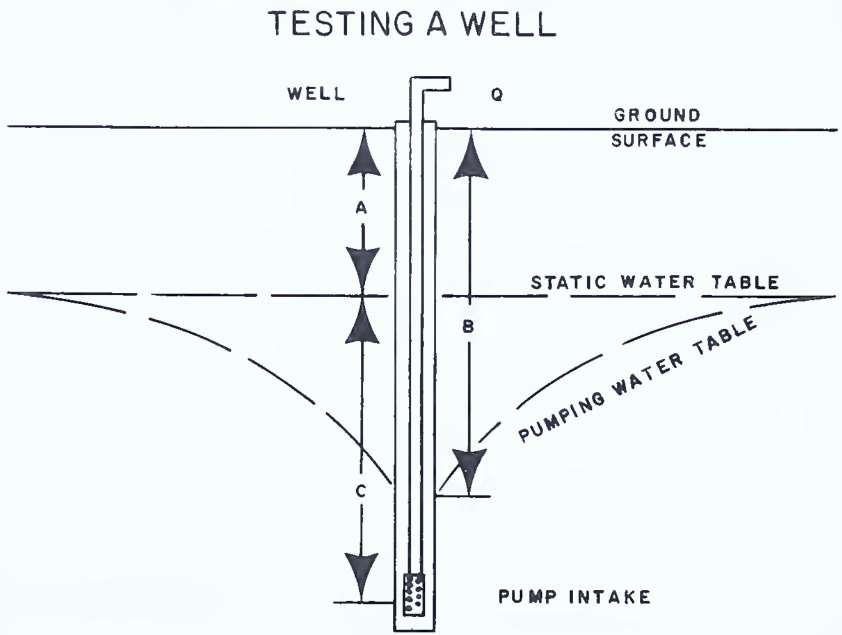

Figure 7. Diagram showing how specific capacity is determined from a pumping test (from Landers, 1976, p. 37).

Table 6. *Summary of Water-Yielding Capability of Rocks*

Rock unit(s)	Specific capacity[1] ([gal/min]/ft): Number of wells	Specific capacity[1]: 25 Percent	Specific capacity[1]: Median	Specific capacity[1]: 75 Percent	24-hour median specific capacity[2] ([gal/min]/ft)	Depth to water (feet): Number of wells	Depth to water (feet): Median	Depth to water (feet): Maximum	Available drawdown[3] (feet)	Calculated median sustained yield (gal/min)	Number of wells	Median reported yield[4] (gal/min)
Colluvium	11	3.4	1.4	0.42	1.1	20	45	87	38	42	17	20
Martinsburg Formation — transported												
Carbonate	4	3.3	1.4	.6	1.1	6	31	56	44	48	- - -	- - -
Noncarbonate	12	1.1	.42	.16	.32	21	27	170	48	15	12	10
Martinsburg Formation — normal												
Carbonate	7	.47	.15	.05	.10	10	28	65	47	5	- - -	- - -
Noncarbonate	22	1.8	.78	.32	.51	117	20	125	55	28	95	22
Chambersburg Formation	7	1.7	.2	.09	.15	21	32	70	75	11	9	20
St. Paul Group	22	24	1.4	.09	1.1	39	38	78	75	82	11	15
Rockdale Run Formation	43	33	12	1.4	9	122	30	90	45	405	27	15
Stonehenge Formation	7	14	2.0	.07	1.5	9	37	97	38	57	- - -	- -
Shadygrove Formation	8	2.8	.46	.06	.35	24	43	97	75	26	8	19
Zullinger Formation	18	16	1.5	.25	1.1	51	69	155	75	82	12	15
Elbrook Formation	20	25	3.8	.43	2.9	56	49	143	75	218	4	38
Waynesboro Formation	4	21	5.7	.7	4.3	20	35	125	40	172	4	33
Tomstown Formation	8	130	19	2.6	14	26	54	210	75	1050	15	24

[1] Based on frequency distributions of 1-hour pumping tests. Values shown are exceeded by the indicated percentage of wells.

[2] Based on field data showing average decline of specific capacity.

[3] Based on depth range of median yield zone from Table 5 and the median depth to water. Median casing depth instead of yield zone data used for colluvium. Maximum drawdown allowed is 75 feet.

[4] From well-completion reports filed by drillers.

Tomstown Formation

Information compiled from the rare exposures, borings, and old records indicates that calcareous shale and limestone occur near the base of this formation, that much limestone occurs in the middle, and that massive beds of dolomite are present in the upper part.

The formation is deeply weathered and covered by colluvium to depths of several hundred feet. Water flowing from South Mountain has extensively dissolved the underlying rocks, creating large solution openings and gradually eroding the bedrock surface below the adjacent carbonate rocks. Consequently, the Tomstown Formation is capable of transmitting very large supplies of water to wells. Contemporaneously with the lowering of the bedrock surface, weathered rock debris from South Mountain was deposited on the formation. This unconsolidated material stores additional water that recharges the aquifer and is itself recharged by runoff from South Mountain.

Few wells penetrate the Tomstown, as domestic supplies are usually obtained from the overlying colluvium, often just above the contact with bedrock.

Data on the yielding capability of wells in the Tomstown Formation are given in Table 6. Reported yields are only a fraction of the potential indicated by pumping-test data. The median reported yield of 15 wells is 24 gal/min, whereas the median sustained yield calculated from pumping-test data on eight wells is 1,050 gal/min. Although half of the wells used in the calculation were located and drilled to produce high yields, the remaining wells were randomly located and penetrate only a few tens of feet into bedrock. Even so, the latter wells still produce sufficient water to meet demand.

The use of the median sustained yield throughout the areal extent of the Tomstown Formation may be questionable as the well data are concentrated mainly within 2 miles of Mount Holly Springs, and, here, yield potential may be greatly improved by infiltration from Mountain Creek. However, as geohydrologic conditions appear to be similar throughout the extent of the Tomstown, a similar potential for high yields should exist. Less than 5 percent of the wells in the Tomstown use borehole storage to provide a minimal supply of water for domestic purposes.

Data on depths of water-bearing zones (Table 5) in the Tomstown are deceptive because they include the thickness of overlying colluvium. The median thickness of colluvium penetrated by wells in the Tomstown is 100 feet. Of the 21 wells for which data on water-bearing zones are available, only six penetrate more than 50 feet, and of these only three penetrate more than 100 feet of bedrock. No change in the number of water-bearing zones encountered with increasing depth in the first 200 feet of bedrock was observed. Therefore, wells need to be drilled more than 200 feet in the bedrock, beneath the colluvium, if sufficient water has not been obtained at shallower depths.

Wells in the Tomstown require considerably more casing than most other rock units (Table 5) because of the thick colluvium. Boulders and residual blocks of carbonate rock are often encountered in the colluvium during drilling and may cause difficult drilling, crooked boreholes, or complete loss of the hole. Large, open, or clay-filled cavities, rounded quartzite boulders, or bedrock projections in the borehole also create problems in drilling and well development. However, sustained yields in excess of 1,000 gal/min can be developed in the Tomstown. A public-supply well (Cu–456) has been producing 1,400 gal/min since 1972 without any general decline in water levels. Sustained yields of 450 and 800 gal/min are reported from two other wells in the Tomstown.

Waynesboro Formation

Little is known about rocks in this stratigraphic interval. The bulk of the formation is limestone, according to drillers' reports, but most of the exposed rock in the upper part of the formation is weathered quartzite, siltstone, and argillite.

The Waynesboro underlies uplands, has moderate relief, and is commonly covered by colluvium from South Mountain and alluvium on the Yellow Breeches floodplain. The colluvium is generally much thinner than that overlying the Tomstown and is absent over much of the formation. Most of the effects of colluvium and drainage from South Mountain on the Tomstown Formation may also apply to the Waynesboro Formation where it occurs south of Yellow Breeches Creek.

Insufficient data exist to evaluate adequately the yielding capability of this formation. However, of four specific capacities available, only one is low, and, of the four reported yields, three are far above domestic needs. A median sustained yield of 172 gal/min was calculated (Table 6), and this is probably low because only shallow yield zones were penetrated. The median well depth is only 86 feet, and most wells penetrate less than 50 feet of bedrock. Only two of the seven wells for which data are available on depths to yield zones are more than 100 feet deep. No significant differences in the number of zones encountered occur to depths of 150 feet, the deepest range for which data are reported. Therefore, wells need to be drilled deeper than 150 feet if shallower yield zones have not provided sufficient water for the intended use.

Elbrook Formation

The formation is composed chiefly of calcareous shale and argillaceous limestone interbedded with purer limestone. The Elbrook underlies a large area of rolling uplands that has considerable local relief.

A median sustained yield of 218 gal/min was calculated for this unit (Table 6). However, the highest yielding well in the Cumberland Valley is a public-supply well (Cu–807) in the Elbrook, west of Boiling Springs, which

pumps 2,000 gal/min. About 10 percent of the wells for which data are available are not capable of supplying minimum domestic needs without reliance on borehole storage.

The number of yielding zones (Table 5) encountered decreases rapidly below 150 feet. Therefore, if a well drilled to a depth of 150 feet has not encountered sufficient water, the site probably should be abandoned in favor of a new site.

Zullinger Formation

The Zullinger Formation is a thick, dominantly siliceous, banded limestone. Dolomite interbeds make up about 10 percent of the formation. Sandstone and chert beds in the lower part of the formation underlie a prominent ridge that forms some of the most rugged terrain in the carbonate sequence.

The median sustained yield of this unit is 82 gal/min. Although the potential exists, no production wells are known to yield at this high a rate. The Zullinger is one of the most areally extensive formations in the valley, but, at present, it supplies water only to scattered farms and dwellings. About 20 percent of the wells for which data were available rely on borehole storage to supply domestic needs. Both the rugged terrain and the hydrologic factors discussed below inhibit the development of this unit.

Wells in the Zullinger must be drilled deeper than in other units because water levels in this unit are the deepest in the Cumberland Valley. Deep water levels also require large pumps to provide sufficient lifting ability. Casing requirements are second only to the Tomstown Formation. Yielding zones are deeper than in other units; however, yielding-zone data indicate little variation in the average number of zones encountered to a depth of 450 feet, the maximum for which data are available. Wells need to be drilled at least to these depths to take maximum advantage of yielding potential.

Shadygrove Formation

The Shadygrove Formation is a light-colored limestone that contains widely dispersed interbeds of dolomite. Lithologies of this formation interfinger with those of the underlying Zullinger Formation, and from Carlisle eastward, the approximate contact is shown on Plate 1 as a broken sawtooth line. Gently rolling valleys characterize the terrain over this unit. The median sustained yield of 26 gal/min calculated for this unit makes it one of the poorer yielding carbonate formations. Three of the eight wells test pumped rely on borehole storage to provide a marginally adequate water supply. The only well of large specific capacity (Cu–500) taps a conduit that feeds into Big Spring (Cu–Sp–22).

Water-bearing zones are developed to depths of at least 460 feet. Maximum development occurs above 200 feet, and below this depth the frequency of zones decreases rapidly.

Stoufferstown Formation

The Stoufferstown is a thin limestone composed mostly of recemented carbonate-rock fragments, some as large as cobbles. Conglomerate beds of tabular limestone fragments and thin siliceous seams projecting in sharp relief from weathered exposures characterize this unit.

The narrow rocky, broken ridge that forms on the Stoufferstown discourages development, but makes it an important mapping unit. Pumping-test data are not available from the few wells that may possibly yield from this unit; the maximum reported yield is 12 gal/min. The association of mid-valley springs with this unit and with shallower yielding zones in rocks north and farther along the flow path indicates that a discharging area usually occurs at this stratigraphic level.

Stonehenge Formation

The Stonehenge is a gray limestone containing crinkled laminae throughout; some beds contain scattered carbonate grains and pebbles of carbonate rock. Rolling and rocky lowlands have developed on this formation.

Based on data from seven wells the calculated median sustained yield is 57 gal/min. One production well (Cu-256) has a sustained yield of 125 gal/min. About 20 percent of the wells rely on borehole storage to supply domestic needs.

The maximum development of yielding zones occurs at depths of less than 100 feet, although some zones are present to the maximum depth of reported data.

Rockdale Run Formation

Very light gray, very fine grained, pure limestone is the dominant lithology in the lower part of the Rockdale Run Formation. The middle and upper parts consist mostly of light-gray limestone, commonly containing abundant fine carbonate grains and fossil fragments. Dolomite beds are sparsely dispersed throughout the unit, but occur more abundantly near the top. This formation occupies the largest area of any of the carbonate rocks and forms rolling uplands of low to moderate relief.

Data on the yielding capability of the Rockdale Run Formation are more abundant than for any other carbonate unit, because of its large areal extent and high degree of development and use by man. The median specific capacity of 12 (gal/min)/ft is based on tests of 43 wells and is more than double that of the other carbonates, except the Tomstown Formation. The calculated median sustained yield of 405 gal/min is also second only to the Tomstown. About 5 percent of the wells test-pumped could not supply household demands without the existing borehole storage. Sustained yields of 500 gal/min from Cu-278 and 600 gal/min from Cu-287 are the maximum reported from this unit.

Of the 91 yielding zones reported, 58 are at depths of less than 100 feet and only 7 occur below 250 feet. No large specific-capacity or high-yielding

wells produce from zones below 200 feet. The median well depth is only 82 feet, the shallowest in all rock units in the valley. The shallowness of wells and yielding zones restricts the amount of drawdown available and this reduces the potential sustained yield of the Rockdale Run, even though wells of large specific capacity are common.

Pinesburg Station Formation

The Pinesburg Station Formation is a thin dolomite that is an important control for geologic mapping but is unimportant as a source of water.

Topographic expression varies and is probably a function of the amount of interbedded limestone, the amount of chert contained, and the amount of chert and dolomite in the adjacent rocks. The Pinesburg Station may underlie either narrow low hills or the flanks of broad ridges, or it may straddle a narrow valley.

Specific-capacity data were available for only three wells: 0.03, 0.09, and 66 (gal/min)/ft.

Finely crystalline dolomite, as in this unit, usually does not constitute a high-yielding aquifer (Meisler and Becher, 1971, p. 49). Wells of large specific capacity are possible in the Pinesburg Station at preferred sites, such as Cu-482. Data on yielding zones, well depth, and casing depths (Table 5) are inadequate to make statistical evaluations about construction characteristics of wells in the Pinesburg Station. No large production wells are known.

St. Paul Group

The lower and upper parts of the St. Paul Group are dominantly pure limestone except for minor amounts of dolomite. The middle part consists of darker, less pure limestone and abundant interbanded dolomite and some dolomite interbeds. The group forms gently rolling lowlands of slight relief.

Rocks of the St. Paul Group have a calculated median sustained yield of 82 gal/min. Sustained yields of large production wells are 105 gal/min from Cu-264, 155 gal/min from Cu-466, and 260 gal/min from Cu-460. Twenty percent of the domestic wells in this formation, however, depend on borehole storage to supply even household demands.

Data for the St. Paul show the deepest testing of any unit and the deepest yielding zones encountered in the valley. Although the maximum number of zones is developed at shallow depths, the zones are nearly as abundant down to 250 feet. Between 251 and 550 feet, yielding zones are rare. However, in the 551- to 600-foot depth range, the number of zones per 100 feet of hole sampled is almost as great as in the zone of maximum development.

Chambersburg Formation

The Chambersburg is a dark-gray, thin-bedded limestone that commonly weathers into small cobblestone shapes. It forms gently rolling lowlands of slight relief.

The Chambersburg has the lowest yielding capability of any carbonate formation in the Cumberland Valley. The calculated median sustained yield is only 11 gal/min. No large production wells are known, and the calculated maximum yield is 100 gal/min. Of the wells for which information is available, about 15 percent used borehole storage to provide for domestic needs.

Yielding zones are best developed less than 100 feet below land surface. Below this depth, fewer zones are intercepted in all depth ranges, although the number per depth range stays about the same down to 400 feet.

Pyrite and abundant carbonaceous material in rocks of the Chambersburg cause widespread water-quality problems. Nearly 40 percent of the wells produce water containing hydrogen sulfide and iron.

Martinsburg Formation—Normal (Autochthonous)

West of Carlisle, the Martinsburg Formation consists of an upper and lower member, composed dominantly of dark-gray shale, separated by a middle member several hundred feet thick, composed of graywacke sandstone and siltstone containing shale interbeds. At the base of the Martinsburg is a thin zone of argillaceous limestone and calcareous shale.

The Martinsburg forms uplands generally 90 to 150 feet above the adjacent limestone terrane to the south. The uplands are dissected by numerous small, steep-walled ravines. The middle graywacke member forms a broad dissected ridge generally 25 to 100 feet above the adjacent shale terrane.

Little difference in water-yielding ability exists between the major mappable units of the Martinsburg west of Carlisle. An eight-fold difference does exist between the basal limestone and the remainder of the formation. The noncarbonate rocks have a median calculated sustained yield of 32 gal/min compared with 5 gal/min for the limestone. The maximum sustained yield estimated for the noncarbonate rocks is 75 gal/min. Borehole storage is used to provide adequate amounts of water for household needs from about 40 percent of the wells in the basal limestone. All other wells test-pumped in the Martinsburg were capable of supplying adequate amounts of water, at least for domestic use, without dependence on storage. Short-term production yields of 80, 165, and 200 gal/min are reported from three wells in the upper part of this unit. A yield of 40 gal/min was sustained for 3 weeks from a well in the lower part of the Martinsburg during a pumping test by the U. S. Geological Survey.

Yielding zones are commonly encountered at depths less than 100 feet. Below this depth, the frequency of zones declines gradually to 350 feet. No zones were reported at greater depths.

Martinsburg Formation—Transported (Allochthonous)

East of Carlisle, much of the Martinsburg has been replaced by a heterogeneous collection of rocks that were transported as coherent masses from their original depositional sites. A great variety of red and green shale and

siltstone, coarse sandstone and graywacke, limestone conglomerate, and limestone occur in these units, as well as much gray shale. These rocks are not subdivided into members in this report. The topography of the transported Martinsburg is similar to that of the normal Martinsburg elsewhere. The upland terrain has been extremely dissected by erosion and stands 90 to 150 feet above the adjacent limestone lowland.

The limestone lenses (Plate 1) have about three times the capability of the other transported rocks to yield water. The median calculated sustained yield is 48 gal/min from the limestone lenses, and 15 gal/min from the noncarbonate rocks. All of the wells that were pumped were able to supply normal household demands without using borehole storage. Two public-supply wells, Cu–18 and –662, can produce 50 to 60 gal/min each. Yields of 50 to 90 gal/min are obtained from school wells Cu–267, –299, and –303.

Yielding zones are evenly distributed through the first 200 feet of the transported Martinsburg rocks. Below this depth range, only one zone was reported, though an additional 243 feet of hole was drilled. Yield zones appear to be developed to greater depths than in the normal Martinsburg.

Comparison analysis of specific-capacity data clearly shows that significant differences in yield exist between some Martinsburg rock units. Moderate to large yields can be obtained from the limestone lenses of the transported Martinsburg and from all but the basal limestone of the normal Martinsburg. Only small to moderate yields can be obtained from the remainder of the Martinsburg.

Colluvium

Unconsolidated material along the flank of South Mountain consists of undifferentiated deposits, residuum from rock weathering, talus, and other deposits of mass wasting. They are grouped here as colluvium. Figure 8 is a generalized thickness map of the colluvium. The extremely irregular bedrock surface and the sparsity of data prevent detailed mapping. In general the colluvium is thickest on the mountain slope near the contact between quartzitic rocks rimming South Mountain and the Tomstown Formation. The material thins in the downslope direction and grades into the normal regolith overlying the valley. In some areas the weathered bedrock occurs at the surface surrounded by colluvium. In other areas the colluvium attains a maximum reported thickness of 450 feet.

Wells in the colluvium are cased to the yielding zone, which may be in sand or gravel, but more commonly is just above the bedrock. Water can enter the well only through the open bottom of the casing, and, therefore, the yielding potential determined from pumping tests on these wells is probably less than the true potential. The median calculated sustained yield of this unit is 42 gal/min. All wells pumped are more than able to supply domestic needs. No high-yield wells produce from the colluvium.

Figure 8 General distribution and thickness of colluvium on the flank of South Mountain

Epler Formation

The Epler Formation of the Lebanon Valley sequence is correlated with the Rockdale Run Formation of the Cumberland Valley sequence. The few hundred feet in the upper part of the Epler that occurs between faults that bound it on the north and south are dominantly limestone having subordinate interbeds of dolomite. The unit forms a gently rolling valley of small extent.

Data are insufficient to calculate a median yield for the formation. A median estimated yield, based on the data from this and other areas and on the geologic setting, is 25 to 50 gal/min. One well is capable of a sustained yield of 130 gal/min.

Myerstown Formation

The Myerstown is a thin, dark-gray, dense limestone that commonly has very thin interbeds of dark-gray shale. Only a few tens of feet of the Myerstown occurs between the faults that limit it on the north and south. It is correlated with the Chambersburg Formation. The thinness and small areal extent of this unit preclude an evaluation of its yielding ability. Sustained yields of about 10 gal/min, comparable to those of the Chambersburg, are probable.

CHARACTER AND HYDROLOGIC SIGNIFICANCE OF MINOR GEOLOGIC STRUCTURES

Groundwater occurs in the openings created by many processes, from those active in the earliest formative period of the rock's history to those now active. In the Cumberland Valley, openings that contain and transmit water are principally bedding, joints, cleavage partings, faults, and openings enlarged by solution. Any, all, or none of these types of openings may be present at any site. Accessibility is dependent upon the areal and vertical distribution, spacing, and orientation of the openings.

Bedding

Bedding thickness within each of the carbonate rocks is more variable than between them. In addition, bedding inhibits flow across the strike and enhances flow parallel to strike, a fact well documented (Longwill and Wood, 1965, p. 19; Poth, 1972, p. 19; and many others). However, if bedding surfaces are important water-bearing horizons, then, because wells in gently dipping rocks will penetrate more bedding surfaces, they should have greater yields than wells in steeply dipping rocks. A comparison of specific capacities of wells grouped according to whether the local dip of beds was

greater or less than 65 degrees revealed no difference. A comparison of wells in overturned beds versus those in upright beds also showed no difference. Only wells in areas of folding or in areas where the strike of the beds was nearly perpendicular to the regional strike were different. Such wells have median specific capacities that are about double those of other wells.

Cleavage

The carbonate rocks contain a cleavage developed to a varying degree during folding of the strata. This cleavage trends northeast, parallel to the axis of the fold, and is steeper in the upright limb than in the overturned limb, so that it fans about the hinge. Intensity of cleavage decreases upward through the rock sequences so that, at the stratigraphic level of the St. Paul Group, little cleavage is observed relative to the older, cleavage-dominated units such as the Elbrook Formation. Cleavage affects the shale more than the limestone. Dolomite, the most competent rock in the sequence, shows little effect of cleavage, but generally contains a nonpenetrative, widely spaced fracture cleavage genetically related to the regional cleavage. Cleavage is more intense in the shale of the Martinsburg Formation than in the adjacent, more competent, carbonate rocks, but has the same geometry. In some shale zones, cleavage completely obscures bedding.

Cleavage is important in creating water-bearing openings, mostly in the Martinsburg and the shaly parts of the Elbrook and Waynesboro Formations. Generally, it is an annealing phenomenon that inhibits solution in the carbonate rocks. In the shale units, cleavage provides numerous closely spaced, commonly minute openings, which individually cannot provide much water to wells but collectively almost always are capable of providing domestic supplies.

Joints

Joints in the carbonate rocks of the Cumberland Valley sequence occur as rectangular sets, in which the individual joints are vertical to nearly vertical, spaced from 1 to several feet apart, and commonly filled with calcite. The sets are parallel and perpendicular to the strike of bedding, and the perpendicular set is more pronounced. Commonly, either one or both of the sets will deviate considerably from the ideal orientation. The development and geologic significance of joints in these rocks has been discussed by Root (1971, 1977). In the shale of the normal Martinsburg, joints are more closely spaced, ranging from a few inches to a foot apart, and are generally unfilled. Transported Martinsburg shale displays multiple joint sets of complex origin.

Carbonate rocks of the Lebanon Valley sequence exhibit two prominent joint sets. The joints are a few feet apart and are commonly calcite filled.

Three sets of joints, commonly unfilled and spaced from a few inches to a foot apart, are present in the shale of the Martinsburg.

FRACTURE TRACES

Faults and minor geologic structures, such as joints and zones of concentration of fractures, may produce linear features which are visible on aerial photographs and are called fracture traces. Studies of wells drilled on such linear features (Lattman and Parizek, 1964; Hollowell and Koester, 1975) indicate that much higher yields can be obtained here than from other sites.

Fracture traces were identified and plotted on 1:20,000-scale aerial photographs, and then transferred to Plate 1 to show the approximate locations, general orientation, and distribution of such linear features. The traces were not field checked, however, and selection of actual drilling sites must be made in the field using aerial photographs. Geologic knowledge and skill in interpreting aerial photographs is important to the successful application of this method of well-site selection.

Well Exploration and Test Drilling

Information is available on 10 boreholes drilled on fracture traces in the carbonate-rock aquifer. Four were drilled for test purposes by the U. S. Geological Survey, two are irrigation wells of Shippensburg College, and three are wells drilled for public supply in South Middleton Township. One other well was located on a fracture trace unintentionally. Two holes are reported to have missed the fracture trace and encountered only fresh, unbroken rock. At least seven of the 10 holes penetrated solution openings and zones of broken rock, but they also penetrated a greater thickness of fresh and unbroken rock. All but one hole penetrated at least three, and as many as seven, water-bearing openings. One very shallow well penetrated a single large opening. A summary of the important characteristics of these wells and several other nearby wells that were not drilled on fracture traces is given in Table 7.

Wells on fracture traces at the Shippensburg site were drilled no deeper than necessary to provide a yield of about 100 gal/min and did not exceed 150 feet. These sites cannot be considered adequately tested for maximum yield capability. At the Otto site, Cu–677 could not be developed or test pumped adequately. A 30-foot mud- and water-filled cavity was penetrated at a depth of 165 feet. The well was drilled with an air rotary drill, and the cavity could not be cleared because of insufficient air pressure. An attempt to case out the cavity failed when the bottom of an inner slotted casing could not be driven past a depth of 180 feet. A later pumping test on the well produced muddy water and a specific capacity of 3.3 (gal/min)/ft. Problems of well completion and development of this type can occur on

Table 7. *Characteristics of Wells Used in Fracture-Trace Evaluation*

Well number	Depth (feet)	One-hour specific capacity ([gal/min]/ft)	Pumping rate (gal/min)	Topographic position	Number of yield zones	Orientation of fracture trace
			Shippensburg Site			
Cu–673	144	5.7	82	Hillside	3	N45W
674	60	11	100	Valley	1	N77W
675	150	7.8	76	Hillside	3	No trace[1]
335	68	33	143	Draw	1	[1]
337	142	2.5	50	Flat	1	No trace[1]
339	105	15	125	Draw	2	[1]
341	105	5.7 (12 hrs)	75	Draw	2	[1]
			South Middleton Site 1			
454	550	0.1 (est.)	- - -	Flat	0	[3]N50E
456	705	160	200	Flat	6	N50E, N42W
392	164	630	25	Hillside	2 (or more)	No trace
658	135	2.8	180	Valley	?	No trace
			South Middleton Site 2			
807	298	500	20	Valley	6	N51E, N44W
402	?	170	7	Draw	?	[2]N44W
			Bucher Site			
676	200	1.6	20	Flat	3	N58E
318	280	4.4	16	Hillside	?	No trace
320	67	10	7	Valley	?	No trace
			Otto Site			
677	199	1.3	25	Hillside	7	N15E, N45E
678	760	.04 (est.)	3	Hillside	1	No trace
			Hoke Site			
682	200	30	20	Valley	6	N86W
Plugged	100	.025 (est.)	—	Valley	0	[3]N86W
260	285	.03	10	Hilltop	?	No trace

[1] Site selection based on the occurrence of water and fractured rock during excavation for construction.
[2] Reported to be off trace.
[3] Unintentionally located on fracture trace.

fracture-trace sites, especially at the intersections of two fracture traces. Such sites should be avoided if only small yields are being sought.

Fracture traces associated with the two Shippensburg wells and the four U. S. Geological Survey test wells do not have topographic expression. The exact site of a fracture trace is difficult to locate accurately in open fields distant from landmark controls. After the first location on the Hoke property penetrated only fresh, unbroken rock to a depth of 100 feet, the position of the fracture trace was reevaluated and a second location was chosen 25 feet southeast of the first site.

The median specific capacity of all 10 wells located on fracture traces is 8.3 (gal/min)/ft. If the two wells reported to be off the selected trace and the one unintentionally located on or very near a trace are excluded, the median specific capacity is 11 (gal/min)/ft. Either value is considerably better than the median of 3 (gal/min)/ft for all carbonate-rock wells. The median values for all fracture-trace wells also compare favorably with the median value of 4.4 (gal/min)/ft for the 11 nearby wells that are not located on fracture traces. Sites of at least three, and possibly as many as seven, of these 11 wells were located using criteria thought to indicate greater yield potential, rather than for engineering convenience.

RELATIONSHIP BETWEEN TOPOGRAPHY AND YIELDING CAPABILITY

Topography appears to be a significant factor affecting the potential yields of wells on fracture-trace sites. Although the data are insufficient for complete analysis, fracture-trace wells located in valleys appear to have much larger specific capacities than those in other topographic positions.

Many studies (Meisler and Becher, 1971; Wood and others, 1972; Nutter, 1973) have evaluated the relationship of topography and well yield. In general, wells in higher topographic positions have smaller yields than wells in lower positions. Valleys and draws form where the rocks are most susceptible to physical or chemical weathering, and hilltops form on the more resistant rocks. Physical properties of rocks that promote weathering are related to the abundance of minor structural features such as bedding, joints, and cleavage. Chemical weathering is primarily related to mineral solubility, although other factors can be significant. Lower topographic positions are the collecting areas through which all upslope water eventually must drain, and, therefore, these lower areas must have a capability for handling greater amounts of water for each unit volume of rock than topographically higher positions.

Analysis of the relationship between topography and the specific capacities of wells gave results similar to those of earlier studies.

Valley wells have much higher, and hilltop wells much lower, specific capacities than wells in other topographic positions. The influence of topog-

raphy on yielding capability is also much greater in the Ordovician than in the Cambrian carbonate rocks and is probably related to the generally shallower depth of yielding zones in the Ordovician rocks than in the Cambrian rocks.

HYDRAULIC CHARACTERISTICS AND WELL INTERFERENCE

Competition for the same water occurs when wells are too closely spaced. Interference is the result of overlap in drawdown and reduces the yield of any well within the area influenced by pumping from another well. In general, well interference increases as the spacing of wells decreases. Drawdowns in the area influenced by a pumping well are determined from the transmissivities and storage coefficients of aquifers. Table 8 summarizes the transmissivities determined from pumping tests, groundwater recession curves, and specific-capacity data, and gives theoretical drawdowns for the hydraulic properties most representative of the various aquifers. The storage coefficient for the carbonate aquifer is equal to the specific yield determined previously. Storage coefficients for the Martinsburg are assumed.

Drawdowns in real interference problems will vary from theoretical drawdowns because of the heterogeneous nature of these aquifers and recharge from precipitation. In fractured-rock aquifers, interference will be greatest along some preferred direction, generally parallel to bedding, cleavage, joints, or solution features, whichever is the dominant direction of interconnection.

Table 8 can be used to obtain a general idea of the spacing necessary to minimize interference between wells. Drawdowhs for any discharge rate can be calculated from the table because drawdown is directly proportional to discharge. For example, doubling the discharge will double the drawdown.

QUALITY OF GROUNDWATER

Groundwater in the northern Cumberland Valley is of good quality for most uses. Routine field determinations of specific conductance, hardness, and pH of water are listed in the record of wells (Table 13) and the record of springs (Table 14). Water temperatures range from 10 to 14.5 °C and vary little annually.

A direct relationship exists between specific conductance and both dissolved solids and hardness due to calcium and magnesium ions. Therefore, to calculate the approximate value even though a laboratory chemical analysis is not available, multiply the specific conductance by 0.60 to obtain the dissolved solids in milligrams per liter and by 0.48 to obtain the hardness in milligrams per liter as $CaCO_3$.

Values of pH range from 5.8 to 8.2, although about 90 percent are only slightly above or below the neutral value of 7.0. A summary of the specific

Table 8. *Summary of Hydraulic Properties and Theoretical Drawdowns Typical of the Aquifers*

Aquifer	Transmissivity (ft^2/day)	Storage coefficient	Discharge (gal/min)	Days pumped	Drawdown, in feet — Distance from pumped well: 100 ft	500 ft	1000 ft
Martinsburg Formation — transported Carbonate	200	0.04	50	30	12	1.8	0.3
				90	16	5.1	1.5
				180	18	7.0	2.3
Noncarbonate	50	- - -	- - -	- - -	- - -	- - -	- - -
Martinsburg Formation — normal Carbonate	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Noncarbonate	100	.01	30	30	18	5.4	2.1
				90	25	10	4.0
				180	28	13	7.0
	300	- - -	- - -	- - -	- - -	- - -	- - -
Ordovician carbonates	1,000	.05	100	30	7.1	2.5	0.9
				90	8.8	4.2	2.3
				180	9.2	5.1	3.1
	2,300	- - -	- - -	- - -	- - -	- - -	- - -
	8,600	- - -	- - -	- - -	- - -	- - -	- - -
Cambrian carbonates (except Tomstown Formation)	500	.05	200	30	25	7	1.1
				90	33	13	5.9
				180	37	17	9.7
Tomstown Formation	4,000	.05	500	30	12	5.6	3.0
				90	14	7.8	5.3
				180	15	9.3	6.6
	10,000	.05	1,000	30	10	5.7	3.7
				90	12	7.5	5.5
				180	13	8.4	6.5
	14,000	- - -	- - -	- - -	- - -	- - -	- - -

conductance and hardness values of well water is given by geologic unit in Table 9. The median values of hardness and specific conductance increase progressively from the Tomstown Formation (oldest) through the Chambersburg Formation (youngest). In general, specific conductance increases as the length of the water's flow path increases. Longer flow paths bring the water in contact with more rock material and provide more time for solution to occur than shorter flow paths. Water from the Tomstown and parts of the Waynesboro and Elbrook Formations is of low specific conductance because the dilute water received from South Mountain has had little contact with soluble carbonate rock. In contrast, much of the water from the St. Paul Group has moved across most of the width of the carbonate valley and has a high specific conductance. Plate 3 shows that the specific conductance is progressively higher northward across the carbonate valley. It also shows areas of excessively high specific conductance that indicate dissolved solids above the natural levels and, where greater than 833 micromhos, above EPA secondary standards.

Water from wells in the normal Martinsburg Formation has a lower specific conductance than water from wells in the transported Martinsburg. The inequality is caused by lithologic differences, mostly the relative abundance of carbonate minerals. No areal trends exist in the specific conductance of water from any Martinsburg rocks because most of the water is discharged locally to a nearby stream.

The carbonate rocks commonly yield very hard water, except the Tomstown Formation, which yields moderately hard water. Water from all Martinsburg rocks is commonly hard, although wells located near and on the slopes of Blue Mountain yield softer water. Similarly, wells in the colluvium on the north flank of South Mountain yield soft to moderately hard water.

Chemical Analyses

The results of 106 laboratory analyses of the major chemical constituents in water from 50 wells and 26 springs are reported in Table 10. Ninety-one of the analyses are of water from the carbonate rocks. Field values for bicarbonate, specific conductance, and pH, when determined at the time of sampling, are substituted for laboratory values. Results of the analyses are summarized in Table 11, using the median values of the chemical constituents in water from each geologic unit that has at least six analyses.

Maximum allowable concentrations in water from public-supply wells, as defined in the National Interim Primary Drinking Water Standards of the U. S. Environmental Protection Agency (1975), are exceeded by one or more constituents in 30 of 99 samples shown in Table 10, excluding those from the gasoline-spill area east of Mechanicsburg. The latter will be discussed in a later section. Iron concentrations exceeded the EPA limit of 0.3 mg/L in 8 of 14 samples from the noncarbonate rocks and in 12 of 54 sam-

Table 9. Summary of Field Determinations of Specific Conductance and Hardness by Geologic Unit

Geologic unit	Number of wells	Specific conductance[1] (micromhos at 25°C)			Number of wells	Total hardness[1] (grains/gallon)[2]		
		10 percent	50 percent	90 percent		10 percent	50 percent	90 percent
Martinsburg Formation—normal	102	458	295	180	102	12	9	5
Martinsburg Formation—transported	20	688	415	171	16	17	10	4
Chambersburg Formation	15	1350	730	490	13	39	17	13
St. Paul Group	27	1300	720	625	26	26	18	14
Pinesburg Station Formation	4	- - -	700	- - -	4	- - -	17	- - -
Rockdale Run Formation	52	900	650	550	49	21	15	13
Stonehenge Formation	6	- - -	625	- - -	6	- - -	16	- - -
Shadygrove Formation	15	1140	622	399	15	23	15	10
Zullinger Formation	30	655	580	503	28	19	14	8
Elbrook Formation	32	750	600	363	30	18	14	11
Waynesboro Formation	15	794	575	71	15	19	14	2
Tomstown Formation	9	645	200	70	9	16	6	<1

[1] Value shown is exceeded by the percent of wells indicated.
[2] Multiply grains/gallon by 17.1 to obtain milligrams per liter.

Table 10. *Chemical and Bacterial Analyses of Well and Spring Water*

(Results in milligrams per liter except pH and as noted)

Spring or well number	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3) as N	Orthophosphate (PO_4) as P	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Noncarbonate	Specific conductance (micromhos at 25°C)	Field pH (except as noted)	TOC (total organic carbon)	Total coliform bacteria[1]	Fecal coliform bacteria[1]	Trace element analysis	Calcite saturation IAP/Keq. (calcite)[2]	Dolomite saturation IAP/Keq. (dolomite)[2]
TOMSTOWN FORMATION																										
Cu- 392	10- 8-74	15.0	8.6	0.34	0.02	22	7.0	0.7	1.4	106	5.1	1.2	0.2	0.86	0.02	104	84	0	180	8.01	---	---	---	---	56	23
793	9- 4-74	12.0	6.2	.57	.01	30	8.8	1.0	.8	140	.7	1.4	.2	1.3	.01	121	110	1	220	7.74	---	---	---	---	46	14
Sp- 10,11	11- 9-71	14.0	---	---	---	24	8.7	4.1	[3]	124	2.1	.2	---	.3	.05	---	96	0	210	8.0	2.5	---	0	---	---	---
Sp- 13	11- 9-71	14.5	---	---	---	22	8.7	7.8	[3]	126	2.5	.5	---	.4	.05	---	91	0	227	8.0	3.0	---	0	---	---	---
Sp- 14	11- 9-71	14.5	---	---	---	24	8.5	6.4	[3]	126	2.2	.9	---	.4	.06	---	95	0	221	8.1	1.5	---	0	---	---	---
Sp- 26	11- 9-71	11.5	---	---	---	25	8.8	4.6	[3]	128	2.1	1.0	---	.1	.04	---	99	0	231	7.9	1.5	---	3	---	---	---
WAYNESBORO FORMATION																										
485	10-18-74	12.5	10	.04	.03	63	15	8.5	1.7	243	15	26	.2	3.2	.01	285	220	29	480	7.31	---	---	---	---	55	17
Sp- 9	11- 9-71	11.0	---	---	---	27	7.0	4.8	[3]	112	4.4	2.1	---	2.2	.06	---	97	5	226	7.8	3.0	---	1	---	---	---
Sp- 12	11- 9-71	11.5	---	---	---	27	7.6	3.2	[3]	112	3.6	2.0	---	2.1	.05	---	99	7	214	8.0	3.0	---	0	---	---	---
ELBROOK FORMATION																										
301	8-26-70	11.1	11	.02	.01	84	17	4.2	3.8	283	28	12	.2	7.7	0	343	280	48	610	7.9	---	---	---	---	---	---
479	9- 6-74	12.0	8.6	.46	0	66	26	3.0	1.3	243	45	14	.1	5.1	.01	359	270	79	480	7.36	---	---	---	Yes	61	33
503	9- 6-74	13.0	9.5	.28	0	54	24	1.5	1.2	252	24	4.3	.3	2.9	0	277	230	34	460	7.39	---	---	---	---	60	37
526	9-19-74	13.5	8.0	.08	0	47	18	3.9	17	206	16	13	.2	5.1	0	266	190	29	445	7.42	---	---	---	---	48	21
536	9-24-74	14.0	7.9	.05	0	41	14	2.0	3.8	155	12	6.2	.2	4.6	0	195	160	35	315	7.51	---	---	---	---	42	14
605	9-26-74	14.0	9.0	.05	0	29	8.8	0.8	1.0	119	4.8	1.8	.2	1.9	.02	128	110	14	220	7.72	---	---	---	---	40	11
676	10-11-74	12.2	8.2	.40	.03	94	27	11	3.0	344	42	22	.3	8.2	.01	402	350	79	690	7.09	---	---	---	Yes	62	26
807	9-10-74	12.0	8.7	.23	0	42	12	1.4	1.6	160	11	3.5	.2	4.1	.01	186	150	24	300	7.50	---	---	---	---	40	11
Sp- 6,7	8- 4-44	12.0	8.9	.01	---	31	9.3	.6	[3]	124	7.0	1.2	.2	1.6	---	125	116	14	225	7.5	---	---	---	---	---	---
Sp- 6,7	2-12-52	13.3	9.6	.01	---	29	10	1.7	2.1	128	7.5	1.9	---	1.3	---	---	113	9	229	7.5	---	---	---	---	---	---
Sp- 6	11- 8-71	13.0	---	---	---	31	8.6	4.6	[3]	128	7.0	2.7	---	1.8	.03	---	113	8	222	7.6	.5	---	1	---	---	---
Sp- 7	11- 8-71	13.0	---	---	---	30	8.7	4.1	[3]	126	6.0	2.7	---	1.8	.03	---	111	8	222	7.7	1.5	---	11	---	---	---
Sp- 24	11-10-71	11.0	---	---	---	35	8.5	4.8	[3]	132	6.7	4.5	---	3.2	0	---	123	15	240	7.6	1.0	---	2	---	---	---
Sp- 30	11-11-71	11.0	---	---	---	60	18	10	[3]	221	22	12	---	7.1	.01	---	224	43	440	7.5	2.5	---	2	---	---	---
Sp- 31	10-18-74	11.2	8.7	.02	.01	69	15	3.4	3.2	241	19	8.9	.3	8.3	.01	281	230	46	480	7.35	---	---	---	---	62	19

ZULLINGER FORMATION

300	7- 2-70	12.5													.07					7.82	9					
428	10- 7-74	15.0	8.1	.05	.01	100	5.6	1.7	1.8	315	15	5	.2	4.3	0	266	270	28	425	7.02				Yes	63	5
463	9-23-74	12.5	8.1	.05	0	97	30	9.0	4.2	365	34	18	.2	11	0	493	370	84	695	7.02					59	25
512	8-12-74	13.0	7.3	.04	.12	57	8.5	2.0	1.5	194	14	6.0	.2	3.0	.01	206	180	34	335	7.35					47	8
555	10- 8-74	13.0	7.5	.05	0	92	23	3.0	1.2	295	37	7.4	.2	9.3	0	327	320	92	590	7.19				Yes	70	29
628	10-23-74	11.5	5.1	.01	.01	46	3.6	2.5	1.4	130	12	6.2	.1	3.0	0	146	130	26	270	7.64				Yes	49	4

SHADYGROVE FORMATION

354	10- 7-74	15.0	7.3	.01	.01	75	11	1.1	1.2	273	10	2.5	.2	3.0	.02	261	230	20	430	7.40					101	36
520	9-20-74	15.0	7.6	.01	0	68	5.9	1.0	0.8	199	14	4.3	.2	4.4	0	236	190	35	395	7.34					61	8
808	7-17-74	11.5	7.6	.02	0	78	9.4	1.4	1.0	222	13	3.7	.3	5.3	.01	272	230	51	395	7.39			0		73	15
Sp- 5	11-11-71	11.0				66	15	8.7	'	224	18	12		7.2	.01		226	43	450	7.4	3.0	140	23			
Sp- 17	11-12-71	11.0				60	14	13	'	228	21	7.5		4.7	0		207	20	420	7.3	2.0	-	3			
Sp- 17	9-13-74	12.0	8.1	.01	0	65	15	2.7	1.6	243	19	8.0	.3	4.3	.01	238	220	34	445	7.31					56	17
Sp- 22	11-11-71	11.0				54	7.6	5.5	'	179	12	5.4		3.3	.01		166	20	310	7.2	2.0	-	4			
Sp- 22	8-20-74	11.5	7.5	.02	0	54	9.2	2.4	1.2	192	12	6.5	.2	3.2	.01	206	170	23	340	7.32					39	6

STONEHENGE FORMATION

445	7-16-74	12.5	8.5	.03	0	90	13	2.9	1.6	281	19	8.1	.3	3.9	.01	284	280	60	490	7.30					86	25
506	9-21-71													2.0					900		5.5	10	6			
Sp- 16	11-12-71	10.5				82	12	.9	'	262	18	6.6	-	3.9	0		254	40	490	7.2	3.0		2			
Sp- 18	11-11-71	10.5				68	15	3.4	'	232	21	7.3	-	4.6	.01		231	41	400	7.5	1.5		47			

ROCKDALE RUN FORMATION

'190	10- 6-69		8.6	8.0	2.5	92	14	10	2.0	380	4.2	16	.2	0		374	287	0	642	'7.5				Yes		
191	3- 5-51	12.7		.17				55	'	278	80	15		2.0			220	0	623	'7.9				Yes		
191	5-11-70	13.3	8.7	.14	.01	96	16	23	4.3	265	53	60	.1	3.2	.01	503	306	89	790	8.22				Yes		
'193	11- 5-69		9.3	38	4.7	90	12	7.3	1.7	279	4.5	12	.1	0	.01	261	274		497	'7.6						
'212	10-31-69		9.8	17	2.7	110	16	10	2.2	430	5.5	20	.1	.4		368	341	0	704	7.4						
'213	11- 4-69		8.9	1.3	.95	98	12	12	3.1	164	23	21	.1	1.7	.01	245	294		424	'7.7				Yes		
'213	4- 6-70		8.9	.03	.75	100	13	13	3.4	319	26	29	.1	1.5	.01	402	303	42	577	'7.5				Yes		
'215	11- 4-69		9.6	8.6	3.8	100	16	13	3.6	236	2.7	29	.1	.3	0	243	316		471	'7.6						
'224	10-22-69		9.8	1.8	4.7	100	21	4.6	4.7	325	5.1	10	.1	.04	.01	466	328		701	7.3				Yes		
294	7- 1-70	14.0	8.1	.31	.01	97	12	15	5.0	292	38	27	0	4.1	.03	372	292	52	840	'7.6	1					
306	7-22-70		7.5	2.6	.17			5.2	8.1		38	14	.2	5.9	.08		251	59	650	'7.6	2					
308	7-23-70	11.5	6.9	.44	.01			2.5	1.0		15	6.6	.3	5.6	.01		109	39	480	'7.0						
310	7-21-70														.23				440		4					
327	7-12-71		6.1	.01	.02	120	17	94	2.4	235	45	175	.2	1.1	.26	542	240	47	1130	'7.8	2	19	1			
333	9-13-74	13.0	8.4	.1	.15	110	16	4.6	3.4	292	25	17	.3	19	0	411	340	110	725	7.01			0		55	10
411	9-12-74	13.0	7.7	.13	0	90	22	4.9	4.0	352	22	14	.3	7.4	.01	389	320	62	650	7.00			1		53	16
477	9- 5-74	12.5	7.2	.15	0	120	9.4	1.5	1.0	302	11	8.3	.2	6.0		301	340	100	525	7.07					71	9
484	9-25-74	12.0	9.6	.04	.01	140	12	4.7	9.0	377	29	12	.2	15	.02	395	400	100	775	6.77					47	[illegible]
547	10- 4-74	12.0	8.8	.04	0	110	16	15	1.1	379	25	42	.2	1.8		352	340	39	700	6.92					54	10

Table 10. (Continued)

Spring or well number	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3) as N	Orthophosphate (PO_4) as P	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	Field pH (except as noted)	TOC (total organic carbon)	Total coliform bacteria[1]	Fecal coliform bacteria[1]	Trace element analysis	Calcite saturation IAP/Keq. (calcite)[2]	Dolomite saturation IAP/Keq. (dolomite)[2]
												ROCKDALE RUN FORMATION														
Cu- 607	9-27-74	14.0	7.2	.06	0	83	15	1.6	.8	308	16	5.7	.2	4.6	---	338	270	27	540	7.13	---	---	---	---	63	17
615	10-25-74	14.0	8.4	.08	.06	100	12	14	3.6	312	53	25	.2	3.8	.02	392	300	56	645	7.00	---	---	---	---	54	8
650	12- 7-71	11.0	---	---	---	---	---	---	---	---	---	---	---	9.5	.01	---	---	---	550	---	1	5	0	---	---	---
Sp- 4	11-11-71	11.0	---	---	---	90	13	12	[3]	259	32	26	---	6.4	.24	---	278	66	600	7.5	2.5	---	12	---	---	---
												PINESBURG STATION FORMATION														
260	5- 6-70	11.7	7.8	.17	0	111	20	2.5	.8	283	27	7.4	.1	7.9	0	361	361	128	650	7.6	---	---	---	---	---	---
Sp- 29	11-11-71	11.5	---	---	---	95	13	13	[3]	300	34	12	---	5.5	.02	---	291	45	590	7.5	3.5	---	23	---	---	---
												ST. PAUL GROUP														
264	6-30-70	14.5	13	.18	.02	124	8.4	14	2.6	284	86	30	.3	5.2	0	398	344	112	625	'7.2	3	---	---	---	---	---
304	6- 9-70	---	---	---	---	---	---	---	---	---	---	---	---	16	---	---	---	---	---	---	100	---	---	---	---	---
397	8- 3-74	12.0	7.9	.46	.02	150	12	40	5.2	328	33	97	.2	13	.01	636	420	160	980	6.80	---	---	3	Yes	46	4
460	10- 2-74	14.0	7.6	.29	.05	110	17	15	1.9	351	50	20	.2	4.9	.04	426	340	68	660	6.92	---	---	93	Yes	54	11
595	9-27-74	13.0	8.1	.04	.01	84	8.5	6	2.2	273	31	14	.1	2.4	.02	310	240	29	540	6.97	---	---	---	---	38	3
639	11-12-71	12.2	---	---	---	---	---	---	---	976	---	---	---	.3	.49	---	---	---	1575	---	37.5	---	---	---	---	---
651	12- 7-71	12.8	6.1	.69	.01	94	13	18	2.3	282	34	36	.2	6.3	.01	344	288	57	710	'7.8	2	11	1	---	---	---
665	7-16-74	15.5	9.4	7.8	---	150	22	27	11	473	37	65	.1	.01	.01	558	470	77	1050	6.9	---	---	0	Yes	---	---
Sp- 2	11-12-71	12.5	---	---	---	100	19	34	[3]	335	45	51	---	2.5	.03	---	328	53	754	7.2	3.5	---	205	---	---	---
Sp- 2	12- 9-71	12.6	---	---	---	---	---	---	---	---	---	---	---	---	.18	---	---	---	725	---	4	950	26	---	---	---
Sp- 3	11-12-71	12.5	---	---	---	97	18	34	[3]	331	45	44	---	2.8	.04	---	316	45	725	7.0	3.5	---	14	Yes	---	---
Sp- 3	12- 9-71	12.8	7.7	.06	.01	112	18	19	2.8	216	40	35	.2	3.8	.04	---	354	---	725	7.6	3	310	11	Yes	---	---
Sp- 19	9-20-61	---	6.4	.04	---	94	14	38	3.2	322	34	44	0	3.2	---	405	292	28	699	7.3	---	---	---	---	---	---
Sp- 19	5- 3-65	---	8.5	.03	.01	96	12	18	2.4	308	34	18	.1	4.5	---	355	289	37	604	7.4	---	---	---	---	---	---
Sp- 19	11- 8-71	12.5	---	---	---	70	12	60	[3]	302	37	37	---	4.6	0	---	224	---	656	7.4	3.5	---	9	---	---	---
Sp- 19	10- 1-74	13.0	7.8	.04	.02	90	12	25	2.4	317	35	21	.3	2.2	---	381	270	26	630	7.05	---	---	---	---	54	9
Sp- 21	11- 8-71	11.5	---	---	---	55	12	63	[3]	295	28	23	---	5.5	.01	---	187	---	610	7.1	2	---	36	---	---	---
Sp- 25	10-24-74	12.0	7.3	.01	.02	82	15	2.0	1.8	289	16	6.9	.2	4.7	0	289	270	43	498	7.19	---	---	---	---	62	16

CHAMBERSBURG FORMATION																										
262	6- 1-70	17	19	.54	.03	128	24	21	1.7	377	63	50	.2	1.2	.03	571	418	109	875	[5]7.3	3	---	---	---	---	---
262	12- 7-71	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	925	---	---	0	0	---	87	56
424	10- 3-74	13.0	12	.34	.01	120	38	63	1.0	310	60	200	.6	.01	0	658	460	220	1110	7.2	---	---	0	Yes	---	---
Sp- 23	11-11-71	12.0	---	---	---	65	16	40	[3]	290	41	8.2	---	6.3	.1	---	228	0	510	7.4	1	---	32	---	---	---
Sp- 23	10-24-74	12.0	6.6	0	0	92	17	2.3	1.6	305	45	7.2	.3	5.7	0	352	300	66	570	7.19	---	---	---	---	70	21
MARTINSBURG FORMATION—TRANSPORTED																										
247	4-22-70	11.7	11	.23	.05	60	7.4	4.0	.4	164	55	4.0	.1	.02	---	255	180	46	440	[5]7.7	---	---	---	---	---	---
259	5- 4-70	12.2	22	.70	.23	17	8.0	5.9	1.0	104	8.2	0.8	.3	0	.02	130	76	0	220	[5]7.5	---	---	---	---	---	---
274	6- 8-70	---	16	1.2	.03	73	7.8	7.0	.9	210	38	13	.1	8.8	.02	280	214	42	458	[5]7.3	9	---	---	---	---	---
778	9-11-74	13.0	12	.01	0	39	12	6.5	.9	163	24	3.3	.2	.26	0	180	150	13	340	7.5	---	---	0	Yes	---	---
MARTINSBURG FORMATION—NORMAL; BASAL LIMESTONE																										
Sp- 1	11-12-71	12.0	---	---	---	119	20	30	[3]	348	48	64	---	5.5	13	---	380	95	890	7.0	4.5	---	78	---	---	---
Sp- 1	12- 9-71	12.3	---	---	---	---	---	---	---	---	---	---	---	6.8	.27	---	---	---	850	---	4.0	253	24	--		
MARTINSBURG FORMATION—LOWER MEMBER																										
295	7-22-70	12.2	26	5.7	.21	28	5.2	4.0	.7	103	8.6	1.5	.1	.04	.22	131	92	7	218	[5]7.1	3	---	---	---	---	---
307	9-25-70	12.5	27	4.0	.45	24	11	6.4	.7	85	46	1.6	.2	0	0	188	105	36	285	[5]7.2	---	---	---	---	---	---
575	7-16-74	15.0	14	.18	.12	51	19	12	1.6	145	68	22	.2	2.1	.01	309	210	87	458	7.2	---	---	---	---	---	---
776	7-16-74	14.0	15	.10	.12	36	18	19	1.8	181	34	7.4	.3	.01	.02	237	160	16	405	7.5	---	---	0	---	---	---
MARTINSBURG FORMATION—MIDDLE MEMBER																										
391	7-18-74	12.5	19	.03	.09	30	12	11	1.2	145	12	3.2	.3	.99	.03	181	120	5	295	7.6	---	---	---	Yes	---	---
690	7-19-74	18.5	15	.29	.18	30	11	5.3	1.2	104	26	10	.3	1.1	.01	183	120	35	280	7.3		---	---	Yes	---	---
MARTINSBURG FORMATION—UPPER MEMBER																										
706	7-19-74	17.5	25	3.2	.37	15	7.3	4.8	.9	79	12	.6	.3	0	.04	107	68	3	165	6.6	---	---	---	---	---	---
717	9-11-74	14.0	22	.47	.41	33	14	11	1.6	138	28	19	.4	.01	.02	219	140	27	375	7.1	---	---	0	---	---	---
757	9-11-74	15.0	15	.10	.18	37	11	7.5	1.6	141	34	4.0	.2	.61	.01	194	140	22	300	7.5	---	---	---	---	---	---
EPLER FORMATION																										
Yo- 840	3-20-74	15.0	---	.01	0	110	12	8.6	3.3	328	2.4	19	---	17.4	0	---	324	--	690	6.5	---	---	0	Yes	---	---
COLLUVIUM																										
509	9-30-71	12.2	11	16	.24	11	7.5	1.5	1.5	62	1.8	5.1	.2	0	.09	84	59	8	125	[5]6.6						

[1] Number of colonies/100 mL of water.
[2] Ion activity product/equilibrium constant × 100.
[3] Na + K combined as Na.
[4] Wells contaminated by petroleum products
[5] pH measured in laboratory.

Table 11. *Median Values of Major Chemical Constituents or Properties in Water from Selected Geologic Units*

Constituent or property	Median values, in milligrams per liter						
	Tomstown Formation	Elbrook Formation	Zullinger Formation	Shadygrove Formation	Rockdale Run Formation	St. Paul Group	Martinsburg Formation, normal
Silica (SiO_2)	---	8.8	7.5	7.6	8.6	7.8	19
Iron (Fe)	---	0.07	0.05	0.01	0.13	0.06	0.29
Manganese (Mn)	---	0	0.01	0	0.01	0.02	0.18
Calcium (Ca)	24	42	92	66	100	96	32
Magnesium (Mg)	8.7	14	8.5	10	15	13	12
Sodium (Na)	---	2	2.5	1.4	10	18	9
Potassium (K)	---	2.1	1.5	1.2	3.4	2.4	1.2
Bicarbonate (HCO_3)	126	160	295	223	302	313	140
Sulfate (SO_4)	2.2	12	15	14	25	37	31
Chloride (Cl)	1	4.5	6.2	6	17	35	5.7
Fluoride (F)	---	0.2	0.2	0.2	0.2	0.2	0.3
Nitrate (NO_3 as N)	0.4	4.1	4.3	4.4	3.5	4.5	0.61
Phosphate (PO_4 as P)	0.05	0.01	0	0.01	0.01	0.02	0.02
Dissolved solids (residue at 180°C)	---	272	266	238	374	390	188
Calcium, magnesium hardness as $CaCO_3$	96	160	270	214	300	292	130
Noncarbonate hardness as $CaCO_3$	0	29	34	29	52	49	25
Number of analyses[1]	6	9 to 15	5 to 6	5 to 8	17 to 23	11 to 17	9 to 11

[1] Number of analyses varies because all constituents listed were not analyzed in each sample.

ples from the carbonate rocks. Maximum EPA recommended manganese concentrations of 0.05 mg/L were exceeded in 10 of 14 samples from the noncarbonate rocks and in 3 of 50 samples from the carbonate rocks. Iron, manganese, and hydrogen sulfide are common problems in all the Martinsburg rocks and in the Chambersburg Formation. Origin and distribution of the hydrogen sulfide is discussed by Poth (1972, p. 24). To a lesser extent, iron and manganese are a problem in water from the colluvium and Tomstown Formation. These constituents impart unpleasant tastes and odors to the water and must be removed for many uses.

None of the 16 samples from the noncarbonate rocks and only four of 80 samples from the carbonate rocks exceeded the EPA recommended limit of 10 mg/L of nitrate (as N). Although only 5 percent of the samples from carbonate rocks are above the limit established for nitrate, the median level of about 4 mg/L for all carbonate rocks, except the Tomstown Formation (see Tables 10 and 11), indicates a widespread nitrate concentration of moderate levels. These amounts are not natural, but are caused by man's activities in the area. Crop fertilizers, cattle feedlots, barnyard wastes, and on-lot sewage disposal systems can contribute nitrates to the groundwater. Increased activity involving these sources will increase the nitrate load as well as other undesirable constituents, unless protective measures are instituted.

A dissolved-solids concentration of 500 mg/L (maximum recommended by EPA) is exceeded by none of the 14 samples from noncarbonate rocks and by only six of the 48 samples from carbonate rocks. The highest concentrations of dissolved solids, as well as most constituents, occur in water from geologic units that are farthest down the flow path and have the shallowest water levels. The existing levels indicate that man's activities are adversely affecting the quality of the groundwater.

Spectrographic analyses for trace elements were made on 20 water samples from both carbonate and noncarbonate rocks, and the results are given in Table 12 in micrograms per liter along with the results of some trace-metal analyses. Some samples exceed limits set by the EPA for the trace elements listed. The limit of cadmium is 10 μg/L, and the concentration in water from well Yo-840 is 22 μg/L. Cadmium is considered toxic, although little is known of its occurrence. No source could be identified for this occurrence, either natural or man-made. Lead values in excess of the EPA limit were for samples taken from wells in the gasoline-spill area and are discussed in a later section.

PROBLEMS

Most water problems are related to water quality rather than availability. Problems of quantity can be alleviated by planned development of the abundant groundwater resources using information in this report for guidance.

Table 12. *Analyses of Trace Elements in Well and Spring Water*

(Results are in micrograms per liter)

Spring or well number	Date of sample	Geologic unit	Dissolved aluminum (Al)	Dissolved barium (Ba)	Dissolved beryllium (Be)	Dissolved bismuth (Bi)	Dissolved boron (B)	Dissolved cadmium (Cd)	Dissolved chromium (Cr)	Dissolved cobalt (Co)	Dissolved copper (Cu)	Dissolved gallium (Ga)	Dissolved germanium (Ge)	Dissolved lead (Pb)	Dissolved lithium (Li)	Dissolved molybdenum (Mo)	Dissolved nickel (Ni)	Dissolved silver (Ag)	Dissolved strontium (Sr)	Dissolved tin (Sn)	Dissolved titanium (Ti)	Dissolved vanadium (V)	Dissolved zinc (Zn)	Dissolved zirconium (Zr)
Cu-63	7-15-74	Zullinger Fm.	6	30	<3	<7	<9	<4	<4	<7	5	<4	<9	<7	6	<2	<6	0	180	<9	<8	<4.0	260	<12
190	10- 6-69	Rockdale Run Fm.	---	---	---	---	---	---	---	---	---	---	---	60	---	---	---	---	---	---	---	---	---	---
191	5-11-70	Rockdale Run Fm.	---	---	---	---	---	---	---	---	0	---	---	0		---	---	---	---	---	---	---	0	---
213	4- 6-70	Rockdale Run Fm.	---	---	---	---	---	---	---	---	0	---	---	0	---	---	---	---	---	---	---	---	0	---
224	10-22-69	Rockdale Run Fm.	---	---	---	---	---	---	---	---	---	---	---	[1]1200	---	---	---	---	---	---	---	---	---	---
391	7-18-74	Martinsburg Fm.	5	160	<2	<4	19	<2	<2	<4	1	<2	<4	<4	14	<1	<3	0	140	<4	<4	<2.0	170	<6
397	8-13-74	St. Paul Gp.	300	52	<1	<3	11	<5	<4	<3	80	<2	<4	20	3	<1	17	0	300	<4	6	<3.0	50	<6
424	10- 3-74	Chambersburg Fm.	4	210	<1	<5	25	<15	<5	<5	4	<2	<5	<5	11	<3	<5	0	2400	<5	<4	<3.0	1700	<7
428	10- 7-74	Zullinger Fm.	26	22	0	<3	<3	<8	<3	<3	26	0	<3	<3	4	<1	<3	0	130	<3	<2	<2.0	40	<4
434	7-15-74	Zullinger Fm.	17	42	<2	<5	<6	<3	<3	<5	18	<3	<6	<5	4	<2	<4	0	160	<6	<5	<3.0	65	<9
455	10-11-74	Zullinger Fm.	8	46	0	<3	4	<8	<3	<3	20	0	<3	<3	2	<1	<3	0	360	<3	<2	<2.0	1000	<4
460	10- 2-74	St. Paul Gp.	380	49	0	<3	15	<10	<3	<3	3	<1	<3	<3	<2	<2	<3	0	380	<3	24	<2.0	20	<5
479	9- 6-74	Elbrook Fm.	15	64	0	<2	6	<3	<2	<2	2	0	<3	3	5	0	<2	0	420	<2	<2	<2.0	1500	<4
529	7-19-74	Elbrook Fm.	13	43	<3	<6	<8	<3	<3	<6	<2	<3	<8	<6	4	<2	<5	0	110	<8	<6	<3.0	93	<10
540	9-19-74	Waynesboro Fm.	47	28	0	0	6	<1	0	0	15	0	0	2	0	0	5	0	13	0	2	<.2	43	0
555	10- 8-74	Zullinger Fm.	4	24	0	<3	<3	<8	<3	<3	20	0	<3	3	3	<2	<3	0	86	<3	<2	<2.0	400	<4
628	10-23-74	Zullinger Fm.	8	22	0	<2	4	<4	<2	<2	6	0	<2	8	<1	0	<2	0	100	<2	<2	<2.0	50	<2
665	7-16-74	St. Paul Gp.	15	100	<4	<10	50	<6	<6	<10	3	<6	<14	<10	<3	<3	<9	<2	210	<14	<10	<6.0	1500	<20
676	10-11-74	Elbrook Fm.	800	57	0	<3	30	<10	<3	<3	1	<1	<3	<3	5	<2	<3	0	240	<3	35	<2.0	<10	<5
690	7-19-74	Martinsburg Fm.	10	75	<1	<3	17	2	<2	<3	5	<2	<4	5	8	<1	<3	0	120	<4	<3	<2.0	2400	<5
778	9-11-74	Martinsburg Fm.	6	340	0	0	36	<3	<2	0	0	0	<2	<2	10	3	0	0	900	<2	<2	<1.0	820	<2
Yo-840	3-20-74	Epler Fm.	---	0	---	---	---	22	<10	---	20	---	---	8	---	---	---	---	---	---	---	---	510	---
Cu-Sp-1	7-16-74	Martinsburg Fm.	25	27	<3	<8	54	<5	<5	<8	<2	<4	<10	<8	<2	<2	<7	<1	230	<10	<8	<5.0	<5	<14
Sp-3	12- 9-71	St. Paul Gp.	---	---	---	---	---	---	---	---	0	---	---	0	---	---	---	---	---	---	---	---	20	---
Sp-3	7-16-74	St. Paul Gp.	26	35	<3	<8	32	<4	<4	<8	3	<4	<10	<8	<2	<2	<6	<1	270	<10	<8	<4.0	5	<13

[1] Analysis of water sample in area of gasoline spill.

Flooding in Areas of Shallow Groundwater

In the northern half of the carbonate valley, water levels are shallower than elsewhere. During periods of recharge in winter and spring, and during extraordinarily heavy precipitation, groundwater levels often rise to or within a few feet of land surface. Subsurface structures such as basements, especially in low-lying areas, are flooded. The structures and their contents are water damaged and a few incidents of foundation collapse due to external subsurface water pressure have occurred.

Many developed areas in the vicinity of Mechanicsburg and eastward to the Susquehanna River have been flooded by groundwater. Locally, the carbonate aquifer has been utilized as a storm sewer by drilling wells to serve as drains for streets, parking lots, and other impermeable surfaces, causing the flooding problem to be aggravated and the groundwater quality to be degraded. Other areas having similar problems were observed in Carlisle, and potential problem areas exist in farmlands overlying the St. Paul Group between Shippensburg and Newville.

Bacterial Contamination

Analyses for fecal coliform bacteria were made on 74 samples of water from 39 wells and 26 springs (Table 10). The four samples of well water from the Martinsburg Formation were free of these bacteria, but water taken from the only spring sampled (in the basal limestone of the Martinsburg) contained large numbers of fecal coliform bacteria. All water analyzed from springs in the carbonate rocks, except for a few at the Huntsdale Fish Hatchery, contained fecal coliform counts ranging from 1 to more than 200 bacteria per 100 mL of water. Bacterial counts were highest in samples from springs in or near urban areas and lowest in rural areas. Fifteen of the 35 wells sampled in the carbonate rocks contained fecal coliform counts ranging from 1 to more than 2,000 bacteria per 100 mL of water. Shallow wells, and wells having little casing, near intensive cattle-farming activities (barnyards, feedlots, etc.) and down gradient from septic systems, are most prone to bacterial contamination.

Bacterial contamination is not a widespread general problem, but, as development of the area intensifies, it could rapidly become a health hazard. At present, the shallow flow system in the carbonate rocks, especially in and down gradient from communities, has been affected. Increased pumping of groundwater will spread bacterial, as well as other, contaminants more widely and into the deeper parts of the flow system.

Gasoline Spill in the Carbonate Aquifer

A mixture of refined petroleum products, primarily gasoline, was found in the carbonate rocks just east of Mechanicsburg in February 1969. About

211,000 gallons was recovered from surface pools, ditches, basements, and wells by March 1971 and a total of 219,000 gallons was recovered by March 1974. Little has been recovered since that time.

A lack of hydrologic information hampered efforts to remove the gasoline, protect lives and property, trace the source, and determine the limits of the affected area. Activity in the early phases of this project, therefore, was concentrated on field operations and on hydrologic data collection and analysis in support of a State task force. Analysis of the data has provided insight into the complex way the carbonate aquifer functions in a small area and how it is affected by this type of pollutant.

The gasoline accumulated just east of Mechanicsburg in a narrow groundwater subbasin that is oriented parallel to the strike of bedding. Figure 9 is a map showing the geology, well locations, gasoline recovery wells, and approximate limits of gasoline occurrence. Across strike, to the north and south of the subbasin, no petroleum product or odor was detected in the aquifer. Parallel to the strike, either some petroleum product or its odor was detected within half a mile east or west of the area of accumulation. Drainage from the subbasin is entirely subsurface and eastward to the place where the north branch of Cedar Run begins to flow, about 3,300 feet east of Kunkle Lane. A thin film of gasoline or a gasoline odor was detected intermittently in Cedar Run.

Twenty-four of the 45 wells that existed in the area or were drilled to monitor and recover gasoline were productive. Ten of these wells have yielded a thousand gallons or more of gasoline each, and five of the 10 wells have yielded a total of 180,000 gallons or 82 percent of the total amount recovered from all the wells. The five highly productive wells are roughly aligned and nearly parallel to the strike of bedding and cleavage. It would seem, therefore, that openings related to bedding and/or cleavage surfaces are the primary controls that influenced the accumulation of gasoline. Fracture traces parallel to the trace of bedding and cleavage may indicate the location of some of these openings. Some fracture traces are parallel to joint sets measured in the area, but others have no known structural relationship.

The topographic and bedrock surfaces (Figures 10 and 11) affect the gasoline accumulation because their shapes are also controlled by the geometry of zones of weakness in the rock. In general, the bedrock surface slopes to the north. Data from borings and outcrops just north of Trindle Road infer a reversal in slope, as bedrock elevations here are above 410 feet. Therefore, the axis of a trough in the bedrock surface parallel to bedding probably occurs just south of Trindle Road. The topographic map shows a pattern similar to the bedrock map, although differences in detail do exist. Both maps clearly show the influence of the northeast-trending joints and fracture traces. The bedrock map shows a small trough that probably formed along joint(s) oriented parallel to their northwest trend, from the vicinity of the Gill Baer well (Cu-226), south across the Penn-Central Rail-

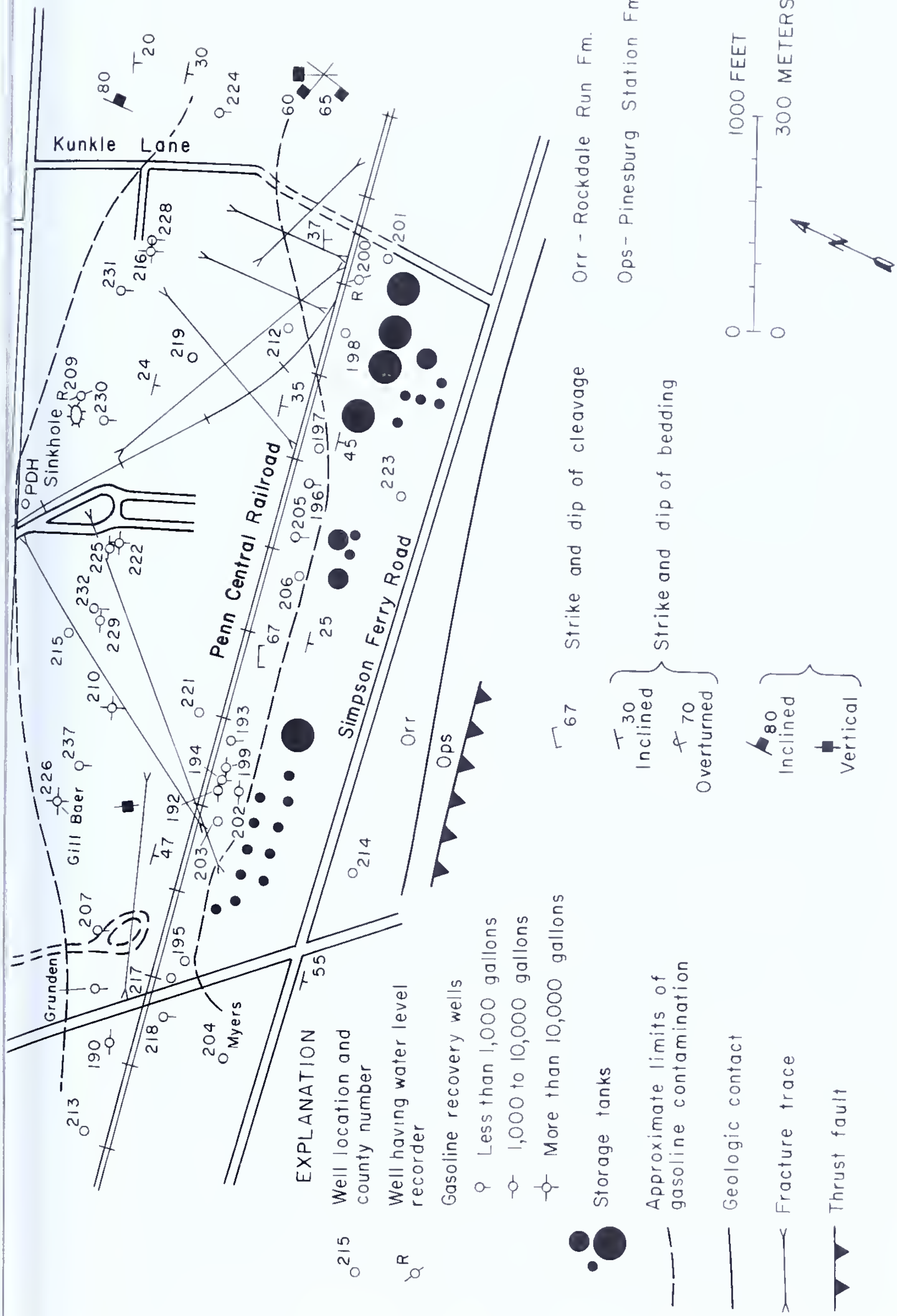

Figure 9. The gasoline-spill area near Mechanicsburg, showing geologic and well information.

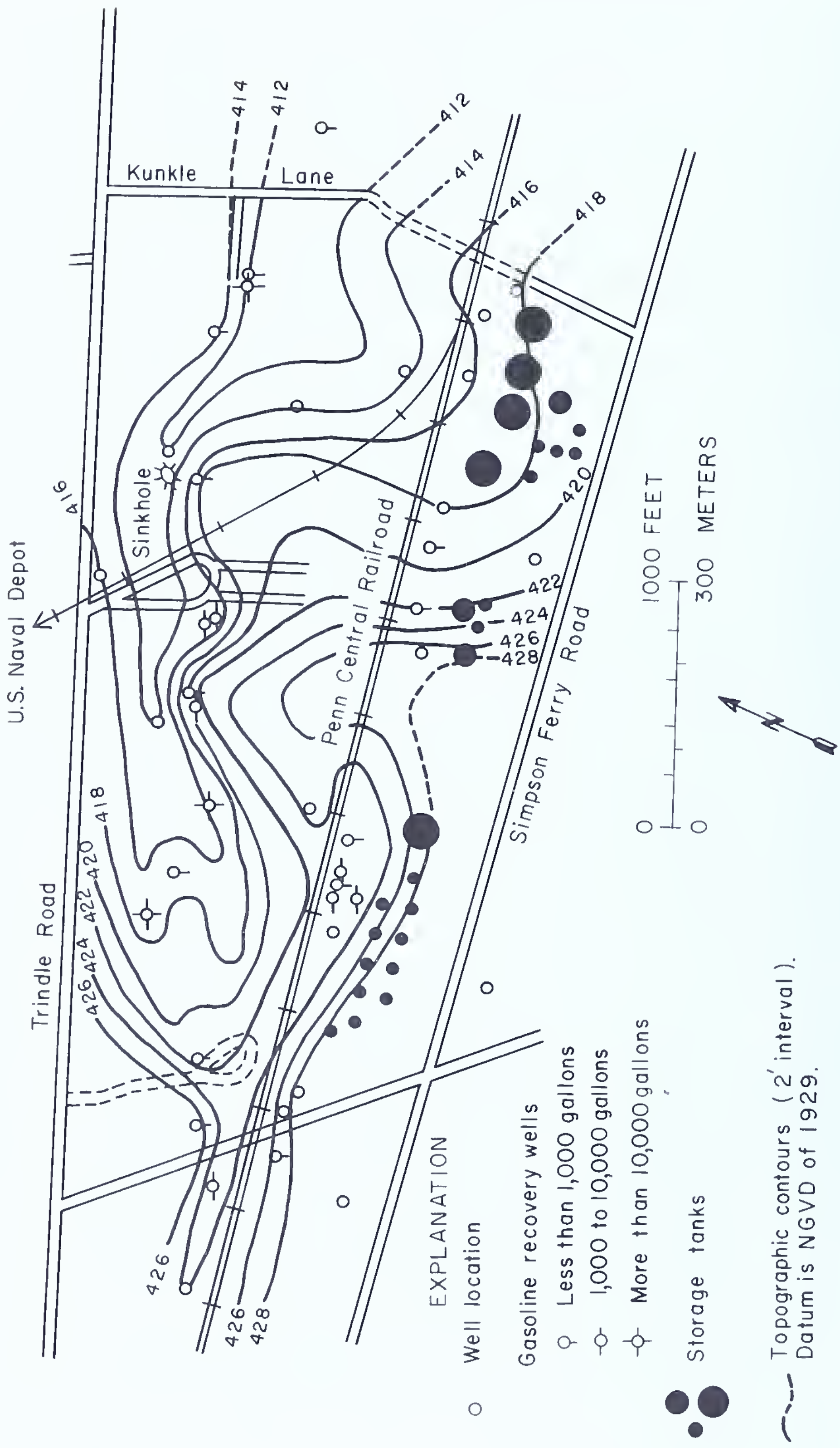

Figure 10. Topography of the gasoline-spill area.

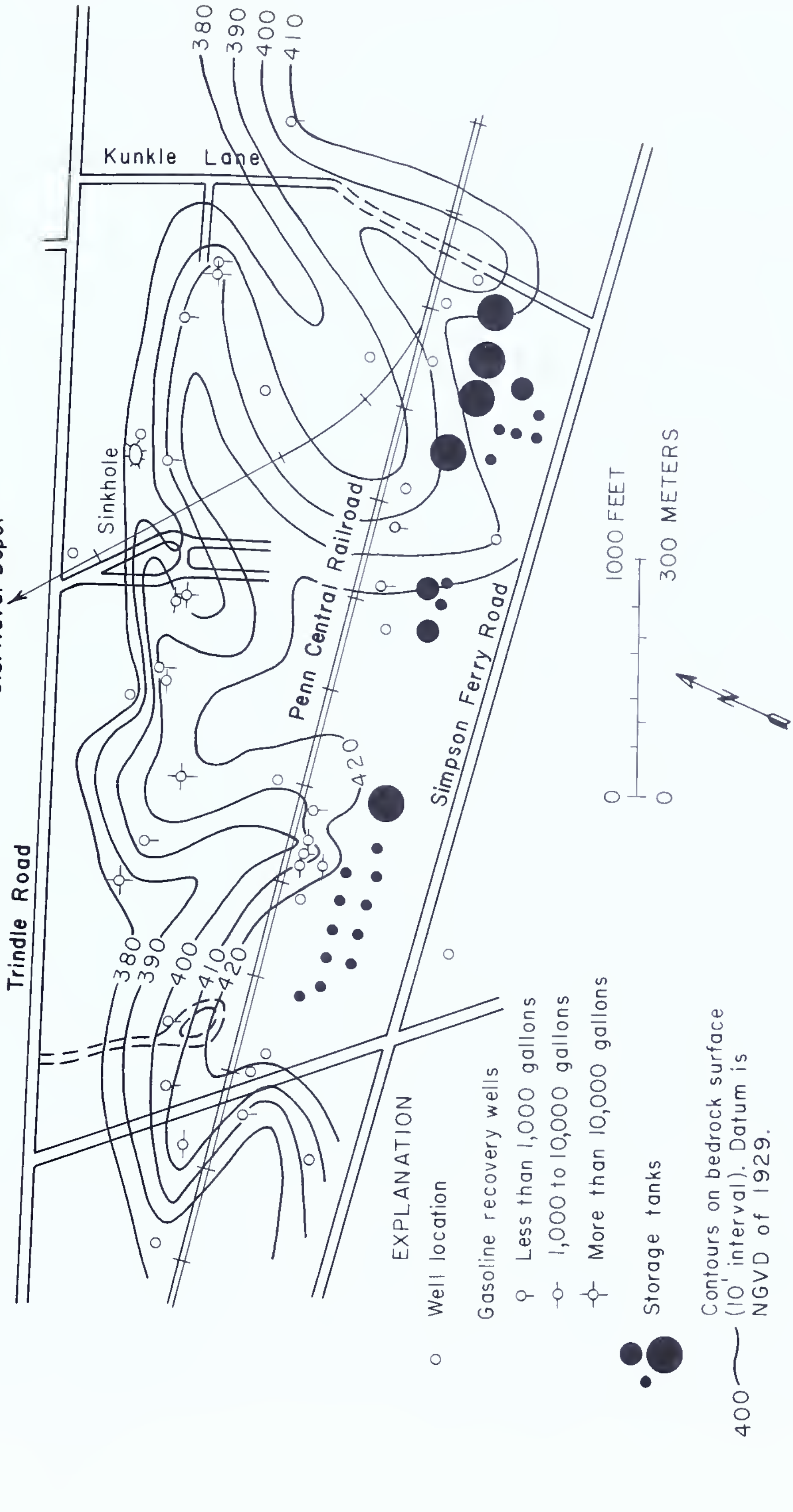

Figure 11. Bedrock surface of the gasoline-spill area.

road. Immediately east of this trough both maps show a high that suggests an area more resistant to weathering than elsewhere.

Figures 12 and 13 show the potentiometric surface during periods of low and high groundwater levels, respectively. The potentiometric and topographic surfaces are similar. The high on the bedrock and topographic surfaces mentioned earlier also occurs on the potentiometric surface.

A broad, flat trough through the area of maximum gasoline accumulation and recovery existed on the potentiometric surface on September 14, 1970. It narrowed to the east and west. The shape and spacing of the contours indicate a long, narrow area of high transmissivity, roughly parallel to the strike of bedding, flanked by much lower transmissivities across the strike. Figures 12 and 13 also show the approximate line of contact between the potentiometric and bedrock surfaces. South of the line, the potentiometric surface is in bedrock. In the vicinity of all major recovery wells yielding gasoline, except the Gill Baer well, the potentiometric surface was in bedrock at that time. A few days earlier, gasoline recovery had abruptly increased from less than 100 to 1,000 gal/day. In contrast, on March 1, 1971, the potentiometric surface was in the soil zone in the vicinity of all wells yielding gasoline, except Cu–202 and –210. Less than 10 gal/day was being recovered at that time. These relationships suggest that the gasoline was being stored in shallow cavities and fractures in the carbonate rock. Any gasoline stored in the soil horizon was held closely and released slowly.

The principal control on gasoline-yielding capability from these wells is the occurrence of openings in the borehole wall that are within the zone of water-level fluctuation. Yields were greatest when the level of the gasoline floating on the water surface coincided with a borehole opening during a declining groundwater stage. However, yields gradually tapered off and increased again only after another cycle of fluctuation in groundwater levels. This suggests that the gasoline was trapped in discrete pools that were shifted around during the rise and fall of the groundwater levels. Figure 14 illustrates the relationship between groundwater stage and gasoline pumpage. Most of the gasoline recovery from the main zone of concentration occurred in the fall, when the groundwater stage was declining and water levels ranged between about 393 and 405 feet above NGVD (National Geodetic Vertical Datum). Rising stages usually resulted in major declines in gasoline recovery, although some rises of a few feet stimulated increases for short periods of time.

Effects of Gasoline on Water Quality

Water routed through this small basin was unfit for most uses, aesthetically undesirable, and possibly toxic. All wells in the contaminated area, and at times the surface water in Cedar Run, had a strong odor of gasoline. Gasoline is soluble in water to about 80 mg/L, and as little as 0.005 mg/L

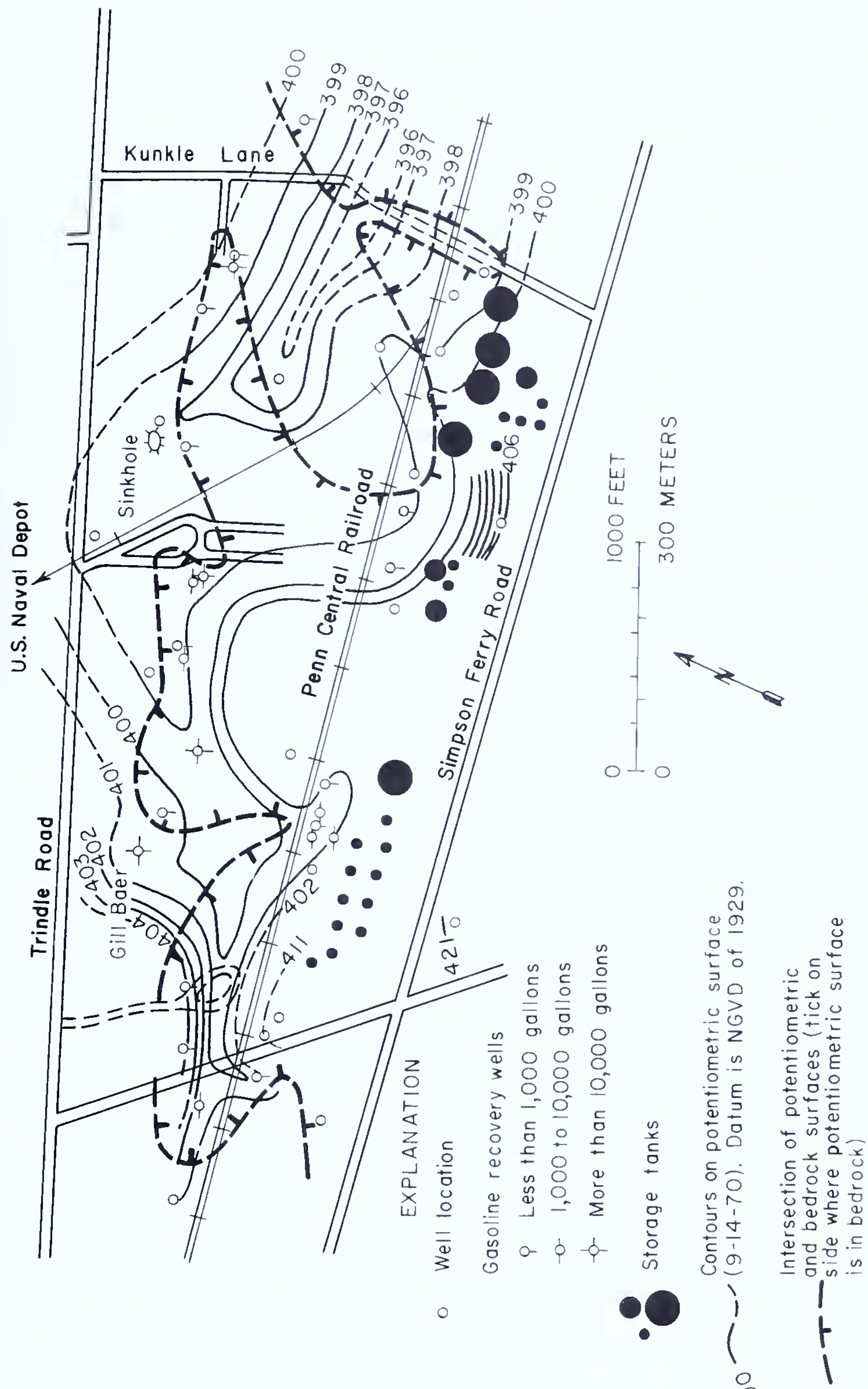

Figure 12. Potentiometric surface on September 14, 1970, in the gasoline-spill area.

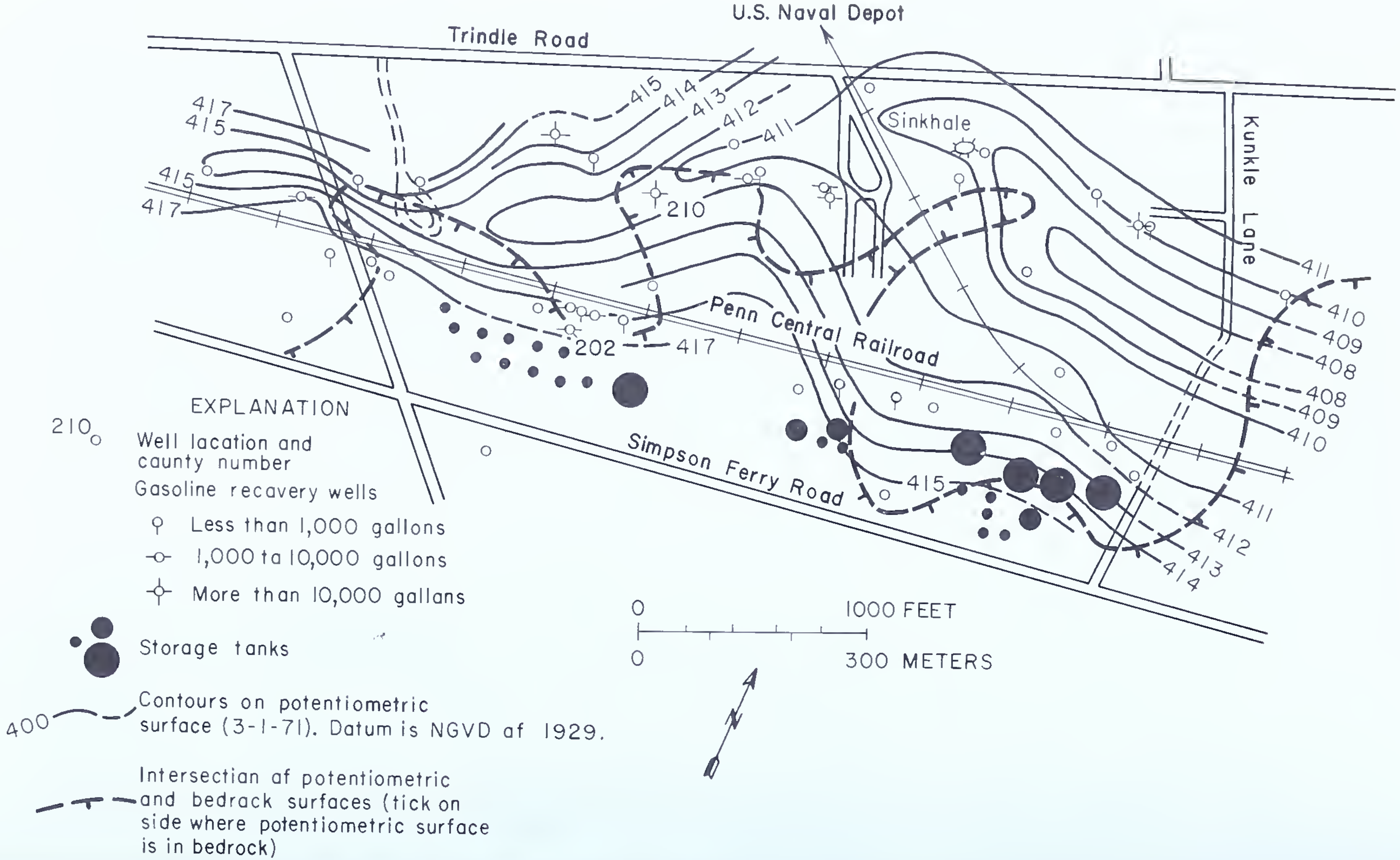

Figure 13. Potentiometric surface on March 1, 1971, in the gasoline-spill area

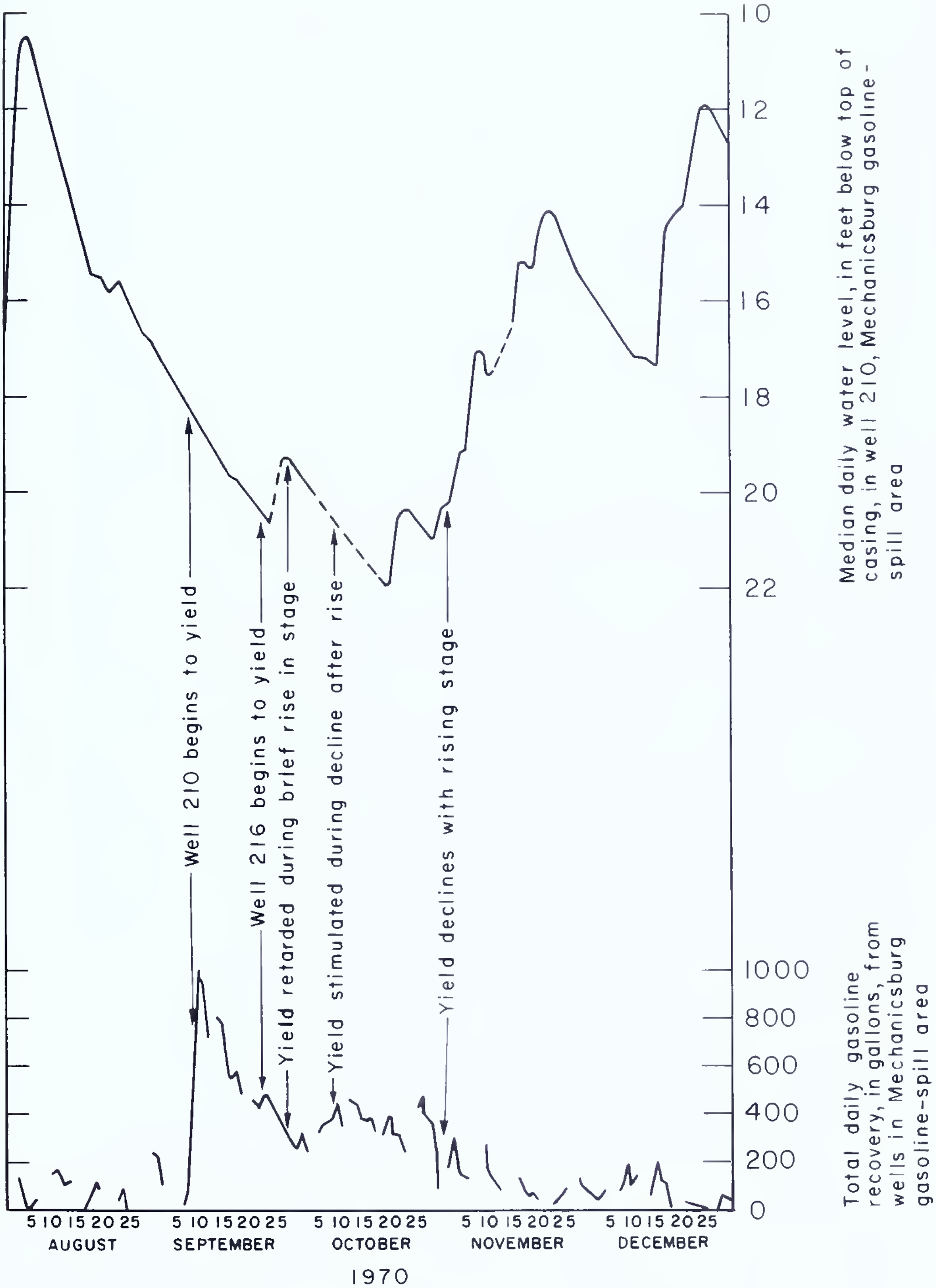

Figure 14. Relationship between groundwater levels and gasoline recovery in the Mechanicsburg gasoline-spill area.

can be detected by taste. Chemical analyses show other effects of the gasoline on water quality.

Based on median values, water (six samples) from wells in the contaminated area contains 50 times more iron and 270 times more manganese than water (five samples) from wells in carbonate rocks of adjacent areas. In the contaminated area, maximum values of 38 and 4.7 mg/L for iron and manganese, respectively, were present. All samples taken in the fall of 1969 exceeded the EPA's drinking water limits of 0.3 mg/L iron and 0.05 mg/L manganese. A single resample taken during the high-water stage in the spring of 1970 had an iron value of 0.03 mg/L and a manganese value of 0.75 mg/L. Two samples of recovered gasoline had iron values similar to those in the water samples, but manganese values of only 0.02 mg/L were found. Probably the metals were extracted from the soil by the gasoline and transferred to the water by complexing with the organic fraction. Some lead from the tetraethyl lead in gasoline was also transferred into the water. Two of the three water samples that were analyzed contained concentrations of lead in excess of the EPA limits, and one had a lead concentration of 1.2 mg/L. Analyses of recovered gasoline showed that over 400 mg/L of lead is retained.

CONCLUSIONS

Large quantities of water can be obtained from openings formed along bedding and joints in carbonate rocks, especially where enlarged by solution. Colluvium on the north flank of South Mountain enhances the yielding ability of the underlying carbonate rocks in the Tomstown, Waynesboro, and Elbrook Formations by serving as an extra storage container and by releasing water that dissolves the carbonate rocks. Sustained yields of more than 1,000 gal/min are now being obtained from wells in the Tomstown and Elbrook Formations and are potentially available from the Waynesboro and Rockdale Run Formations and the St. Paul Group. Well yields in excess of 400 gal/min can be obtained from rocks of the Stonehenge and Zullinger Formations. The Shadygrove Formation can supply 150 gal/min, but the Chambersburg is capable of supplying less than 100 gal/min to wells. East of Carlisle, the transported Martinsburg can produce up to 100 gal/min from wells in carbonate-rock lenses, but only up to about 40 gal/min from the noncarbonate rocks. The basal limestone member of the Martinsburg is able to supply little water to wells, but the remaining noncarbonate rocks can provide yields up to 75 gal/min.

Most of the water in the carbonate aquifer moves north or northeast and discharges through springs into Conodoguinet Creek. Groundwater, amounting to at least 30 percent of the total flow of Yellow Breeches Creek, moves northward under the creek. Some of the water, after moving under

the creek, is discharged to it through Boiling Springs, Baker Spring, and numerous small perennial springs. An average of about 9,000 gal/min continues to move under the basin divide and discharges from Big Spring into the Conodoguinet Creek basin. The diabase dike that extends northward across the valley from Boiling Springs is a major groundwater divide that acts like a leaky dam and separates western and eastern parts of the carbonate aquifer. Folds and faults may divert the flow of groundwater to the surface or the reverse. Shale, siltstone, and other noncarbonate lithologies in the Cambrian carbonate rocks tend to inhibit the flow of water.

The storage coefficient of the carbonate rocks in the Conodoguinet Creek basin in the zone of water-table fluctuation is estimated to be about 0.046, from calculations of specific yield. Storage coefficients for deeper parts of the aquifer are smaller. Transmissivity estimates for the carbonate aquifer range from about 500 to 14,000 ft^2/d (square feet per day). Transmissivity values for the Martinsburg Formation are much smaller, less variable, and average about 200 ft^2/d, or 100 ft^2/d for the transported Martinsburg. Production wells that sustain high yields should be spaced at least 500 feet apart to avoid the overlapping-drawdown and reduced-yield effects of mutual interference.

Wells located in lower topographic positions have greater yield potential than those in higher topographic positions. Those on fracture traces have much greater yield potential than randomly located wells, but not as great as wells in low topographic positions. Successful use of fracture traces requires careful geologic evaluation of sites in the field.

Groundwater is generally of good chemical quality, although large quantities of calcium bicarbonate cause it to be hard to very hard. The Martinsburg and Chambersburg Formations in places yield water that is unfit for most uses because it contains hydrogen sulfide and excessive iron. Moderate levels of nitrate and the presence of fecal coliform bacteria in water from many wells in the carbonate rocks indicate some degradation of the natural quality. Groundwater in a small trough in the carbonate aquifer near Mechanicsburg was rendered unfit for use by the accidental spill of gasoline.

The most important groundwater problems in the valley are the chemical or bacterial degradation of water quality and the damage to in-ground structures and facilities from groundwater flooding. Problems of quantity are related either to distribution or a lack of groundwater development.

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GLOSSARY

Allochthonous. Pertaining to large masses of rock that have been detached and transported from their site of origin by crustal forces of the earth.

Anticlinorium. A regional fold in rock that is convex upward and contains numerous small folds.

Autochthonous. Pertaining to large masses of rock that have not been transported from their site of origin beyond the movements associated with local crustal deformation.

Axial surface. A surface that connects the axes of each layer in a fold.

Base flow. The fair-weather flow of a stream sustained by the discharge of groundwater.

Colluvium. Any loose, heterogeneous mass of soil material or rock fragments deposited chiefly by weathering and gravity movement.

Diabase dike. A vertical tabular body of diabase igneous rock formed by the intrusion of molten material into a crevice in the surrounding rock.

Drawdown. A lowering of the pressure head or water level in a well as a result of withdrawal of water.

Fecal coliform bacteria. A group of bacteria that live in the intestinal tracts of all warm-blooded animals and are measured as indicators of the pollution of water.

Fecal streptococci bacteria. A group of bacteria that live in the intestinal tracts of all warm-blooded animals, but are less numerous in the human intestine, and are measured as source indicators of the pollution of water.

Fold order. A scale of folding based on wavelength and amplitude of the individual fold.

Fracture trace. Those natural linear features visible on aerial photographs that are believed to be due to the intersection of the surface with a fracture zone in the rock.

Groundwater divide. A ridge in the water table or other potentiometric surface from which the groundwater represented by that surface moves away in both directions.

Joint. A surface of actual or potential fracture or parting in the rock, along which no displacement has occurred.

Metavolcanic. A volcanic rock that has been altered by the physical and chemical processes of metamorphism.

Nappe. A sheetlike allochthonous rock unit originating by thrust faulting or recumbent folding.

National Geodetic Vertical Datum of 1929 (NGVD of 1929). A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada. It was formerly called "Sea Level Datum of 1929" or "mean sea level" in this series of reports. Although the datum was derived from the average sea level over a period of many years at 26 tide stations along the Atlantic, Gulf of Mexico, and Pacific Coasts, it does not necessarily represent local mean sea level at any particular place.

Orogeny. The process by which internal structures within mountain areas were formed.

Potentiometric surface. The surface that represents the static head for water in an aquifer and is generally defined by the levels to which water rises in tightly cased wells.

Specific yield. The ratio of (1) the volume of water that rock and soil, after being saturated, will yield by gravity to (2) the volume of the rock or soil.

Storage coefficient. The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In an unconfined aquifer this value is about equal to specific yield.

Transmissivity. The rate at which water is transmitted through a unit width of the aquifer under unit hydraulic gradient.

Thrust fault. The tilted break surface along which one block of rock has moved upward.

APPENDIX

REGIONAL GEOLOGY

Two named sequences of sedimentary rock of Cambrian and Ordovician age occur in the Cumberland Valley (Figure 3). The sediments that form them accumulated simultaneously, under generally similar environmental conditions, in different parts of the Appalachian depositional basin, but were juxtaposed subsequently during large-scale earth movements. Most of the valley is underlain by rocks of the Cumberland Valley sequence (Figure 2) that form the northwest limb of the South Mountain anticlinorium. The anticlinorium is a complex, overturned, regional fold structure that extends northward from Maryland and plunges moderately to the northeast (Root, 1968). It contains Precambrian metavolcanic rocks in its core and is rimmed by Cambrian quartzites that stratigraphically underlie the Cumberland Valley sequence. Rocks of the correlative Lebanon Valley sequence (Figure 2) occur as a narrow belt in the extreme southeast and were brought into contact with the Cumberland Valley sequence by movement on the Yellow Breeches thrust fault. The rocks on the thrust are part of a regional series of nappes that becomes dominant to the northeast, where it is part of the Reading Prong and associated structures. These rocks are in the westernmost extension of the nappe series.

Cumberland Valley Sequence

Rocks of the Cumberland Valley sequence include limestone and subordinate amounts of dolomite of Cambrian and Ordovician age on the south side of the valley, and shale and graywacke of Middle and Late Ordovician age on the north side (Plate 1). The carbonates constitute a continuous sequence of sedimentary rocks that are estimated to aggregate 13,500 to 16,000 feet; the shale and graywacke add several thousand feet more to the sequence. The valley is bounded on the north and south by steep forested ridges of resistant quartzite and quartzitic sandstone that were not included in this study.

The carbonate-rock sequence, although thick, contains a few thin, key units that aid in interpreting the stratigraphy and structure. The units define several second-order folds that have wavelengths of 1 to 2 miles, amplitudes of as much as a couple of thousand feet, and axial surfaces inclined steeply to moderately southeast. The southeast limbs of anticlinal folds are upright and dip southeast between 15 and 50 degrees. The northwest limbs are generally subvertical or overturned and dip steeply to the southeast. Adjacent to thrust faults, the northwest limb is overturned locally as much as 60 degrees past vertical. Fold hinges are narrow with respect to their limbs. All folds plunge northeast from 10 to 20 degrees. Smaller third- and fourth-order folds, of similar geometries, occur in the larger folds.

From Carlisle to Shippensburg the Martinsburg Formation has the same fold geometry as the carbonate sequence. Abundant fourth-order folds are present in outcrop, but it is not possible to map larger second-order folds, as there are no extensive mappable key beds in this formation. Second-order folds must be present because second-order folds in both underlying and/or overlying rocks project into the Martinsburg.

From Carlisle to the Susquehanna River the structural geology of the Martinsburg Formation is quite complex. Allochthonous slices of sedimentary rocks, deformed in Late Ordovician time by the Taconic orogeny (hereafter designated D_1), were introduced into the Martinsburg depositional basin in this area. These rocks were refolded when the South Mountain anticlinorium was formed early in the Allegheny orogeny (hereafter designated D_2) at the end of the Paleozoic Era. Consequently, there are multiple cleavages, faults of various types and ages, and varied fold orientations and geometries. Joints are equally complex, and have what appear to be nonsystematic orientations that are actually the result of multiple systems that developed at widely different times and under varied conditions. Details of these complex structures are presented by Root and MacLachlan (1978) and Dyson (1967).

A number of large northeast-southwest-trending faults, some having thousands of feet of displacement, developed during D_2 and displaced older rocks northwestward over younger rocks on steep thrust faults that are inclined about 50 degrees southeast. These include the Bonnybrook, Cold Springs, and Reading Bank thrusts (Plate 1). The faults splay into a complex network in units of the Beekmantown, St. Paul, and Chambersburg. Clearly, they extend into the Martinsburg terrane but cannot be mapped because internal stratigraphic control is inadequate.

The New Kingston fault also developed during D_2 folding but its movement ceased early. Initially, it was inclined moderately to the northwest, moving rocks to the southeast, similar to faults near Chambersburg (Root, 1971). Subsequently it was segmented by the southeast-dipping Cold Spring and Bonnybrook thrust faults, which have a longer deformational history. The two small slices of Martinsburg Formation, south of the Pennsylvania Turnpike and several miles east of Carlisle, represent segmented fragments of the New Kingston fault.

The Newville, Stoughstown, Oakville, and Shippensburg faults trend east-west. The first three displace structure on the far side of the fault to the right on planes that are probably subvertical. The Shippensburg fault extends from near Mt. Tabor, Adams County, through the Precambrian metavolcanic rocks of South Mountain, across the Cambrian and Ordovician carbonate rocks and into the Martinsburg terrane, where its identity is lost. A vertical attitude on this fault is confirmed by its linear trace in the high-relief terrane of South Mountain. It is not a simple tear fault, as independent shortening has occurred across the fault, and along some of its ex-

tent structures have been offset across the fault. Some sinistral movement has occurred and the north side is relatively elevated. It may be related to the Carbaugh-Marsh Creek fault near Chambersburg (Root, 1971).

Lebanon Valley Sequence

Parts of only three formations of the Lebanon Valley sequence (Figure 3) are present in the narrow belt of the Yellow Breeches thrust sheet extending from Shepherdstown east to New Cumberland (Plate 1). The Yellow Breeches thrust sheet truncates structures of the South Mountain anticlinorium on a low-angle fault surface that generally dips southeast at only a few degrees and locally, near Mechanicsburg, is horizontal. The structural features of the thrust sheet are complex because they were produced by several different periods of deformation.

Strata of the thrust sheet are part of the inverted limb of a regional nappe and dip moderately to the southeast, as does the pervasive cleavage. Some fourth-order macroscopic folds having nappe geometry are present, but the gross structure is homoclinal. At the thrust-fault surface, and for a few hundred feet above, some of the minor earlier folds are reoriented and some minor folds have developed parallel to the direction of thrusting. Thrusting is considered to have occurred a short time after the South Mountain deformation (D_2), late in the Allegheny orogeny (hereafter designated D_3). From evidence elsewhere it appears that the time of nappe development is considerably older than the Yellow Breeches thrusting, and occurred during the Taconic orogeny (D_1).

On the thrust sheet, carbonate rocks are separated from the shales by faults that formed during nappe development. The youngest fault in the area is the Allendale fault of Triassic age (D_4). It is a normal fault that dips 60 degrees southeast, has about 650 feet of displacement, and extends across most of the thrust sheet.

STRATIGRAPHY

Cumberland Valley Sequence

Tomstown Formation

The lithology of this formation is very poorly known because it is rarely exposed. The only good exposure is in an abandoned quarry just south of Williams Grove, where 50 feet of rock in the upper part of the formation is well exposed. Here, dark-blue-gray and dark-gray, silty, mottled dolomite occurs in massive beds. Elsewhere in the county at this approximate stratigraphic horizon, massive dolomite that weathers dark rusty brown or dark gray is sparsely exposed. Little is known of the underlying lithology. Borings for the foundation of the PPG Industries plant at Mt. Holly Springs encountered much blue-gray limestone in what should be the medial part of

the unit. Old records of iron-ore mining operations at the foot of South Mountain indicate that calcareous shale and limestone occur near the base of the formation. The thickness is estimated to be 1,000 to 2,000 feet.

Waynesboro Formation

Little is known about the Waynesboro Formation in Cumberland County, as there are few exposures. The best exposures are near the top of the formation and occur between Brandtsville and Leidighs in Monroe Township. About 100 feet of rock is exposed sporadically here and consists of thick beds of very fine grained, reddish-brown, weathered quartzite, which contains worm burrows and ripple marks. The quartzite is interbedded with medium-thick beds of green-gray and reddish-green-gray, weathered siltstone and silty argillite. Near Dickinson some of the siltstone beds contain bands of well-sorted and -rounded, very coarse grained quartz sand. Dark-gray, tough, silty argillite and some limestone beds are also present near the base of the unit. The bulk of the formation is probably carbonate, although most exposures are noncarbonate. The contact with the underlying Tomstown is indistinct, as the lithologies of both units are so poorly known. Generally, the greater topographic relief of the Waynesboro is used as a guideline in separating these units. Estimates of the thickness of the Waynesboro range from 1,000 to 1,500 feet.

Elbrook Formation

Good exposures of this formation are scarce. However, most of the unit appears to be composed of thick to massive beds of platy, highly calcareous shale and argillaceous limestone that are light gray with a bluish cast and weather to buff brown. Beds of light-buff to pink or light-blue-gray stromatolitic limestone, containing some oolites, quartz, and silt occur near the top and continue into the overlying Zullinger Formation. Continuous exposures across the contact with the Zullinger Formation can be seen about 1.3 miles northeast of Mooredale (Plainfield 7-1/2-minute quadrangle), where no distinct differences in lithology were observed. Shaly limestone, typical of the Elbrook, can be found on both sides of the contact as well as massive limestone beds that are more typical of the Zullinger. The contact here is drawn in the valley that separates the prominent ridges underlying each of the units. Lithologies characteristic of each of these units appear to interfinger across the valley through a zone at least 500 feet thick. Dolomite and dolomitic shales occur sparingly throughout the unit. In the medial part of the Elbrook is a thick sequence of medium-blue-gray limestone having sparse dolomitic laminae. Some local beds of calcite-cemented, fine- and coarse-grained sandstone and slightly calcareous, shaly siltstone are present, principally in the lower part, and form prominent but discontinuous ridges. It is estimated to be 3,500 feet thick from the outcrop width corrected for bedding attitude.

Zullinger Formation

The Zullinger Formation is the oldest carbonate rock sufficiently exposed to describe adequately. It consists of thick to massive beds of dark-blue-gray limestone, typically containing abundant crenulated siliceous seams, and less commonly having siliceous bands that weather in relief. Many thin- to medium-thick limestone beds contain edgewise conglomerate, oolites, or coarse calcareous sand detritus. Zones of stromatolites and fossil detritus are also present. Thick beds of laminated to mottled dolomite that weather to a buff color are common. Some beds of dark-blue-gray, calcite-cemented, coarse-grained quartz sandstone that weather buff brown occur locally. These beds are commonly cyclical. Each cycle begins with coarse detrital beds and grades upward into beds containing finer detritus and eventually into fine-grained dolomite. For a detailed discussion of these cycles, see Root (1968, p. 16). Lighter colored, thick limestone beds, similar to those in the overlying Shadygrove Formation, occur throughout the unit and are especially abundant at the top, so that selection of the upper contact is difficult in some areas. East of Carlisle, both formations interfinger across a broad zone, and selection of the contact is so difficult that it is shown (Plate 1) as a broken sawtooth line. A thickness of about 2,500 feet is calculated for the formation.

Shadygrove Formation

The Shadygrove Formation is characterized by thick to massive beds of light-blue-gray limestone. Some beds have a pinkish cast, are stromatolitic, and contain, in sparse amounts, brown chert nodules up to several inches across and small white quartz rosettes. Thick beds of banded buff-blue-gray and light-blue-gray, mostly fine grained limestone, containing patches of fine detrital material, are abundant. Locally the beds also contain seams of coarse-grained quartz sand. A few thick beds of finely laminated, gray and buff dolomite are present. In a few areas, very thick interbeds of calcareous, very coarse grained quartz sandstone occur. The hills formed by these resistant beds are littered with bright-orange-brown fragments of leached sandstone. A maximum thickness of 800 to 1,000 feet is typical for this formation, but interfingering with the Zullinger Formation causes difficulty in determining thickness.

Stoufferstown Formation

The Stoufferstown is a medium-gray, thin- to medium-bedded limestone composed dominantly of carbonate detritus. The detrital particles range in size from clay to cobbles, but are mostly sand or pebbles. Thin beds of edgewise conglomerate composed of tabular limestone fragments, commonly 2 to 3 inches in length, characterize this unit. Many beds are oolitic. Patches of dolomite, half an inch or less in diameter, that weather bright orange are also a distinctive feature. Dark-gray seams composed mostly of silt- and

sand-sized quartz, cemented in places by secondary silica, often project in sharp relief from weathered exposures. These seams form a distinctive lithology and are important in the recognition of the Stoufferstown. Where the seams do not crop out, they form a surficial soil composed of dark-colored, hard shaly chips. Thickness and the regionally persistent character help to distinguish the Stoufferstown from other similar rocks. A narrow, rocky ridge is formed on the Stoufferstown where dips of bedding are moderate to steep. The combination of ridge topography and abundant rock exposure inhibits the development of the land, resulting in a broken ribbon of woods across otherwise heavily farmed land. Distinctive lithology, abundant exposure, and wooded topography make the Stoufferstown one of the key mapping units in the carbonate sequence.

The Stoufferstown is approximately 200 feet thick in Cumberland County, a thickness that compares favorably with the 220 feet measured at Chambersburg (Root, 1968). However, south of Carlisle, the dark siliceous seams and edgewise conglomerates are sparse, and the formation is difficult to map. Farther east, the Stoufferstown is commonly less than 200 feet thick.

Stonehenge Formation

The Stonehenge Formation is typically a medium-bedded, very fine to fine-grained, light- to medium-gray limestone containing abundant zones of detrital and skeletal carbonate material. Closely spaced, crinkled, siliceous dolomite laminae occur throughout the formation. Some interbeds of buff-weathering dolomite, 1 to 3 feet thick and containing sparse black chert nodules, occur near Harrisburg. This formation weathers into isolated pyramidal blocks that stand as much as several feet above ground surface. Thickness is estimated to be 500 feet where a complete section occurs.

Rockdale Run Formation

The lower one fourth to one third of this formation is distinguished by abundant very light gray to light-pinkish-gray, finely laminated to homogeneous, medium-bedded limestone. Indistinct to fairly well defined stromatolitic structures are commonly preserved in association with large, very light gray to buff chert nodules that weather out as rounded or blocky cobbles and small boulders. Locally, beds of arenaceous limestone occur near the base of this formation so that the contact with the underlying Stonehenge Formation is difficult to determine in a few places where typical lithologies of both formations interfinger. Where the Rockdale Run lithology entirely replaces the Stonehenge, the Rockdale Run Formation directly overlies the Stoufferstown.

The upper two thirds to three quarters of the Rockdale Run Formation consists principally of light-gray, medium- to thick-bedded, very fine grained, detrital and skeletal limestone. The detrital fragments may range

up to pebble size, and texturally these limestone beds are breccias. A few beds of limestone contain dispersed quartz-sand grains. Lowermost beds of the upper part of the formation are thick-bedded, medium- to coarse-grained, detrital limestone that locally contains skeletal grains and larger fragments. Buff-orange- to brown-weathering, argillaceous silty dolomite interbands are spaced from a few inches to a few feet apart throughout the limestone and weather in slight relief. Thick beds of buff-brown-weathering dolomite are distributed sparsely throughout this sequence. In the upper portions, light-gray-weathering, thin- to medium-bedded, very fine grained limestone, containing fine- to medium-grained detrital material, occurs. Locally, these beds contain skeletal and stromatolitic components. Crinkled dolomitic laminae occur throughout the unit. Exposures weather into pyramidal forms similar to the Stonehenge Formation.

In the upper few hundred feet, blue-gray and light-gray, bioturbated limestone having small buff patches occurs in quantity. These beds contain abundant white "cauliflower-shaped" rosettes composed of microscopic milky quartz grains in a banded concentric structure. Estimates based on the width of outcrop and dip of bedding indicate that the Rockdale Run Formation is between 2,000 and 2,500 feet thick. This is a reasonable estimate as the formation is 3,000 feet thick at Chambersburg (Root, 1971).

Pinesburg Station Formation

The Pinesburg Station Formation is composed of massive beds of dolomite that weathers buff orange and light gray to medium light gray with a brownish hue. The beds are sparsely banded, but commonly have no sedimentary structures. In the lower part, small white quartz rosettes, similar to those in the uppermost Rockdale Run Formation, and some larger nodules of black to dark-gray chert occur. A few interbeds of blue-gray limestone are also present. The dolomite is generally lighter in color than dolomite in the other formations and is characterized in weathered exposures by closely spaced, crisscrossed fractures that have been enlarged by solution to depths of about half an inch. Near Mechanicsburg, the Pinesburg Station Formation is 200 feet thick. Calculated thicknesses elsewhere in the area range from less than 100 to 350 feet.

St. Paul Group

The St. Paul Group consists dominantly of light- to medium-gray, thick-bedded limestone and minor amounts of dolomite. A general regional threefold subdivision probably exists (Stose, 1908), but it is not mappable (Root, 1968, p. 38). The lower and upper subdivisions are characterized by thick beds of light-gray, very fine grained limestone. The beds commonly have a network of isolated blebs of clear calcite that may appear darker or lighter than the host rock on weathered surfaces. These rocks are high in calcium and are called "birdseye" limestone. A few thick interbeds of light- to me-

dium-gray dolomite occur. Large cephalopods, coiled gastropods (*Maclurites*), and stromatolites are commonly seen in outcrops. The medial part of the group consists of abundantly fossiliferous, medium-gray, thin-to medium-bedded, cobbly to nodular limestone. The cobbly and nodular beds can be mistaken for the Chambersburg Formation. Some dolomite interbeds, abundantly interbanded buff-gray dolomite, and blue-gray limestone that create a distinctive striped sequence, and black chert nodules and bands are also present in the medial portion.

Along the Susquehanna River at Lemoyne, this unit is about 900 feet thick. At Mechanicsburg it is about 600 feet thick, and just west of Carlisle, along the Pennsylvania Turnpike, it is about 900 feet thick.

Chambersburg Formation

The Chambersburg Formation is composed of dark-gray, thin-bedded, platy to nodular limestone that commonly weathers into distinctive cobbles that litter the ground surface. The formation is poorly exposed, but, according to Dyson (1967), it consists of a basal 150 feet of dark-gray, even-bedded, dense limestone; a medial 335 feet of dark-gray, fine-grained, fossiliferous, nodular limestone in 2- to 3-inch-thick beds; and an upper 170 feet of medium- to dark-gray, fine-grained limestone in 1- to 7-inch-thick beds that are separated by argillaceous partings. Several bentonite beds as much as 2 feet thick occur, and these are mostly in the upper part of the unit. The thickness of the Chambersburg is about 650 feet.

Martinsburg Formation—Autochthonous (Normal)

The Martinsburg Formation is separated into three members west of Carlisle (Plate 1). In the upper and lower members, dark-gray shale is dominant, but thin interbeds of siltstone and fine-grained graywacke are common, especially in the upper member. The shale weathers either into smooth, planar, dark-orange-brown plates if cleavage and bedding are nearly parallel, or into rough pencil-like fragments if cleavage intersects bedding at a high angle. A graywacke member several hundred feet thick separates the two shale sequences. The graywacke is progressively thinner to the east, as coarser grained beds are supplanted by siltstone and shale that cannot be distinguished from similar rocks in the upper and lower parts of the Martinsburg. These rocks could not be traced farther east than about 0.3 mile north of Carlisle Springs. Here the trend of the sequence appears to be toward Blue Mountain, but colluvial cover prevents further observations. The graywacke weathers dark brown, is moderately well sorted, and is fine to medium grained, but it contains some coarse-grained beds. The beds usually range up to several feet thick, but massive beds also occur. Shale interbeds increase towards the top and base of the graywacke sequence.

The base of the Martinsburg is calcareous, reflecting the transition from carbonate to clay deposition, and is termed informally the basal limestone.

This calcareous zone becomes progressively thicker from west to east, and discrete limestone beds are better developed to the east. Where its areal extent is significant, the approximate limits of the calcareous zone are shown on Plate 1. In Cumberland County at Green Spring, North Newton Township, the zone is estimated to be about 150 feet thick, but a little farther east, near Newville, it may be less than 100 feet. In the Newville area the basal limestone is thin, and it consists of dark-gray to black, thin-bedded, orange-brown-weathering, calcareous shale beds and sparse bands of argillaceous or dark-blue-gray, platy limestone beds. At Carlisle the calcareous zone is 300 to 400 feet thick, and it is possibly as much as 500 to 600 feet thick at the Susquehanna River. Here, it consists of beds 1 to 4 inches thick of laminated, platy, blue-gray argillaceous limestone interbanded with 1/2- to 2-inch-thick bands of calcareous to noncalcareous silty shales. A few 1- to 2-inch-thick bands of medium-orange-brown dolomite or dolomitic shale and graded bands of lithic sandstone occur near the base. A few lenses, 1/4 to 2 inches thick, of light-gray-weathering black chert occur near the middle of this unit. The lithology of the basal unit is gradational from the underlying carbonate-rock sequence (Dyson, 1967), and the top is arbitrarily selected at the occurrence of some thick lithic sandstone and graywacke, or, if this is absent, where the lime content is negligible.

Structural characteristics prevent an accurate determination of the thickness of the Martinsburg, but it is conservatively estimated to exceed 1,000 feet.

Martinsburg Formation—Allochthonous (Transported)

East of Carlisle most of the main body of Martinsburg dark-gray shale and graywacke is supplanted by several allochthonous lithic units that resemble rocks in the Hamburg sequence (MacLachlan and others, 1975) east of the Susquehanna River. These units contain coarse, thick-bedded graywacke; extensive belts of platy limestone (Plate 1) in zones 20 to 50 feet thick; local limestone conglomerate and calcareous quartz sandstone; extensive belts of coarsely micaceous, maroon and green mudstones; much green, green-gray, and finely micaceous, medium- to dark-gray silty shale and siltstone; and a single occurrence of massive gray chert (Root, 1977). These rocks have been deformed to a much greater extent than the Martinsburg rocks west of Carlisle (Root and MacLachlan, 1978). Structural complexity prevents any estimate of thickness of the allochthonous units.

TABLE 13. RECORD OF WELLS

Well location. The number is that assigned to identify the well. It is prefixed by a two-letter abbreviation of the county. The lat-long is the coordinates in degrees and minutes of the southeast corner of a 1-minute quadrangle within which the well is located.

Use: A, air conditioning; B, bottling; C, commercial; H, domestic; I, irrigation; N, industrial, P, public supply; R, recreation; S, stock; T, institution; U, unused.

Topographic setting: C, stream channel; D, depression; F, flat; H, hilltop; P, pediment, S, hillside; T, terrace; V, valley; W, draw.

Aquifer: Qc, colluvium; Omu, Martinsburg Formation, upper member; Omm, Martinsburg Formation, middle member; Oml, Martinsburg Formation, lower member; Ombl, Martinsburg Formation, basal limestone; Omac, Martinsburg Formation, allochthonous members; Om, Martinsburg Formation, undifferentiated, Oc, Chambersburg Formation; Osp, Saint Paul Group; Ops, Pinesburg Station Formation; Orr, Rockdale Run Formation; Oe, Epler Formation; Osh, Stonehenge Formation; Ost, Stoufferstown Formation; Csg, Shadygrove Formation; Czl, Zullinger Formation; Ce, Elbrook Formation; Cwb, Waynesboro Formation; Ct, Tomstown Formation; Ca, Antietam Formation.

Lithology: cygv, clay and gravel; dm, dolomite; gv, gravel; ldss, limestone, dolomite, shale, and siltstone; ldu, limestone and dolomite, unknown proportions; ls, limestone; lsds, limestone with some dolomite and sandstone; lsd, limestone with some dolomite; qz, quartzite; sdgv, sand and gravel; sh, shale; shc, calcareous shale, shgw, shale and graywacke; shst, shale and siltstone; slld, shaley limestone and limestone with some dolomite.

Static water level: Depth--F, flowing; +, above land surface. Date--month/last two digits of year.

Reported yield: gpm, gallons per minute.

Specific capacity: gpm/ft, gallons per minute per foot of drawdown.

Hardness: gpg, grains per gallon.

Specific conductance: Micromhos at 25°C, micromhos at 25 degrees Celsius.

TABLE 13.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/lithology
Number	Lat-Long							
								CUMBERLAND
Cu- 15	4013-7652	Sandnes Sons Inc.	---	---	N	310	V	Osp/lsdm
18	4018-7656	Summerdale Water Co.	---	1920	P	450	S	Omac/sh
59	4009-7709	J. E. Cohick	Gillow	1950	H	550	S	Ce/slld
63	4010-7707	Irva Zimmerman	---	---	S	555	S	Czl/lsdm
150	4016-7725	Col. Denning St. Pk.	Harrisburg's Kohl Bros.	1962	R	820	V	Omu/shst
154	4015-7726	J. E. Garman	---	1962	H	665	V	Omu/shst
155	4015-7726	Atlantic Pipeline Co.	Harrisburg's Kohl Bros.	1937	H	660	S	Omu/shst
156	4016-7724	Col. Denning St. Pk.	K. R. Whisler	---	R	855	V	Omu/shst
157	4015-7726	W. H. McCrea, Jr.	---	1946	U	950	S	Omu/shst
158	4016-7725	Col. Denning St. Pk.	---	---	R	820	V	Omu/shst
160	4015-7720	John Keller	K. R. Whisler	1963	H	660	S	Omu/shst
161	4015-7720	J. C. Barrick	---	1963	H	635	S	Omu/shst
162	4015-7720	George Foster	---	1964	H	625	W	Omu/shst
163	4015-7722	Fred Burkholder	K. R. Whisler	1960	H	650	W	Omu/shst
164	4015-7720	Leroy Foster	---	1955	H	610	H	Omu/shst
165	4015-7720	John Chronister	K. R. Whisler	1958	H	611	V	Omu/shst
167	4015-7720	Harry Keller	do.	1958	H	655	S	Omu/shst
168	4016-7720	John Beaston	do.	1955	H	760	S	Omu/shst
170	4016-7720	C. O. Barclay	do.	---	H	760	W	Omu/shst
171	4015-7726	Harry Miller	---	1951	H	770	S	Omu/shst
172	4015-7719	Foster Nelson	Merle L. Gayman	---	H	650	S	Omu/shst
173	4015-7718	Arthur Kech	K. R. Whisler	1964	H	610	W	Omu/shst
174	4015-7719	Isaac Geiger	---	1964	H	650	S	Omu/shst
175	4016-7715	Earl Minnich	---	1965	H	570	S	Omu/shst
176	4015-7721	Smiley Wagner	Merle L. Gayman	1964	H	655	S	Omu/shst
177	4015-7721	do.	---	1964	H	700	S	Omu/shst
178	4015-7726	Albert Miller	K. R. Whisler	---	H	625	V	Omu/shst
180	4015-7726	Norman Reinford	do.	1954	H	640	S	Omu/shst
183	4015-7726	C. C. Miller	do.	1965	H	690	S	Omu/shst
184	4015-7726	F. O. Miller	do.	1964	H	670	S	Omu/shst
186	4016-7725	Newton Landis	do.	---	H	780	S	Omu/shst
189	4016-7726	Wayne Titus	---	1946	H	790	S	Omu/shst
190	4013-7658	Harrisburg Truck Body Co.	Kohl Bros., Inc.	1969	U	422	V	Orr/lsdm
191	4013-7658	Mechanicsburg Naval Depot	---	1942	U	425	F	Orr/lsdm
192	4013-7658	Atlantic Pipeline Co.	Kohl Bros., Inc.	1969	U	423	W	Orr/lsdm
193	4013-7658	do.	do.	1969	U	422	W	Orr/lsdm
194	4013-7658	do.	do.	1969	U	423	W	Orr/lsdm
195	4013-7658	do.	do.	1969	U	430	S	Orr/lsdm
196	4013-7658	American Oil Co.	do.	---	U	419	W	Orr/lsdm
197	4013-7658	do.	do.	1969	U	417	S	Orr/lsdm
198	4013-7658	Gulf Oil Co.	do.	1969	U	416	W	Orr/lsdm
199	4013-7658	Atlantic Pipeline Co.	do.	---	U	423	W	Orr/lsdm
200	4013-7658	Gulf Oil Co.	do.	---	U	417	W	Orr/lsdm
201	4013-7658	do.	do.	1969	U	418	F	Orr/lsdm
202	4013-7658	Atlantic Pipeline Co.	do.	1969	U	424	S	Orr/lsdm
203	4013-7658	do.	do.	1969	U	426	S	Orr/lsdm
204	4013-7658	C. R. Myers	---	---	U	429	F	Orr/lsdm
205	4013-7658	American Oil Co.	Kohl Bros., Inc.	1969	U	422	S	Orr/lsdm
206	4013-7658	do.	do.	1969	U	427	S	Orr/lsdm
207	4013-7658	Sherman Scrap Co.	do.	1969	U	421	V	Orr/lsdm
208	4013-7659	H. H. Brinser	---	---	U	434	F	Orr/lsdm
209	4013-7658	Mrs. H. P. Myers	Kohl Bros., Inc.	1969	U	413	V	Orr/lsdm
210	4013-7658	Gosset Supply Co.	do.	1969	U	416	V	Orr/lsdm
211	4013-7659	Ursini Bakery	do.	1969	U	430	F	Orr/lsdm
212	4013-7658	F. O. Kunk	do.	1969	U	413	W	Orr/lsdm
213	4013-7658	Harrisburg Truck Body Co.	do.	1969	U	425	V	Orr/lsdm
214	4013-7658	Weis Markets Inc.	do.	1969	U	438	F	Orr/lsdm
215	4013-7658	Stocker Property	do.	1969	U	414	V	Orr/lsdm
216	4013-7658	Kunkle Farm	do.	1969	U	411	V	Orr/lsdm
217	4013-7658	Atlantic Pipeline Co.	do.	1969	U	428	S	Orr/lsdm
218	4013-7658	Mumper Real Estate	do.	1969	U	426	S	Orr/lsdm
219	4013-7658	Kunkle Farm	do.	1969	U	413	S	Orr/lsdm
220	4013-7659	A-1 Lincoln Rent-All	do.	1969	U	430	F	Orr/lsdm
221	4013-7658	Pa. Power and Light Co.	do.	1969	U	424	F	Orr/lsdm
222	4013-7658	C. H. Stoner	do.	1969	U	415	V	Orr/lsdm
223	4013-7658	American Oil Co.	do.	1969	U	421	F	Orr/lsdm
224	4013-7658	John Kunkle	do.	1969	U	411	V	Orr/lsdm
225	4013-7658	C. H. Stoner	do.	1969	U	415	V	Orr/lsdm
226	4013-7658	Gill Baer	---	1969	U	417	V	Orr/lsdm
227	4013-7659	Bruce O'Hara	Kohl Bros., Inc.	---	U	430	D	Orr/lsdm
228	4013-7658	E. J. Succa	do.	---	U	---	V	Orr/lsdm
229	4013-7658	Stocker Property	do.	---	U	422	S	Orr/lsdm
230	4013-7658	Pa. Power and Light Co.	do.	---	U	418	F	Orr/lsdm
231	4013-7658	R. L. Clites	do.	---	U	416	V	Orr/lsdm
232	4013-7658	Stocker Property	do.	1970	U	421	S	Orr/lsdm
233	4013-7658	Claypool Homes	do.	1970	U	418	V	Orr/lsdm
244	4012-7703	C. B. Brenneman	Harrisburg's Kohl Bros.	1969	H	445	H	Orr/lsdm

(CONTINUED)

Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level: Depth below land surface (feet)	Static water level: Date measured (mo/yr)	Reported yield (gpm)	Specific capacity (gpm/ft)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH	Well number
COUNTY											
400	---	8	---	---	---	50	---	---	---	---	Cu- 15
300	200	8	---	105	---	50	---	---	---	---	18
112	---	6	110	71	2/57	---	5.9	14	600	7.50	59
219	---	6	---	---	1968	---	---	19	660	6.88	63
100	42	6	---	12	5/62	---	---	9	370	7.1	150
70	21	6	---	8	---	---	.36	4	180	7.0	154
166	---	6	---	19	---	---	.63	8	335	8.0	155
107	20	6	---	13	5/66	---	1.2	4	190	7.2	156
71	16	6	---	18	7/65	---	.19	6	295	---	157
91	---	6	---	19	5/66	---	---	5	240	---	158
140	47	6	---	30	11/63	10	---	---	---	---	160
85	17	6	---	10	11/63	15	---	---	---	---	161
90	26	6	---	29	4/64	20	---	---	---	---	162
85	42	6	---	20	---	20	---	---	---	---	163
70	21	6	---	24	5/66	---	---	1	137	7.6	164
40	29	6	---	---	---	---	---	7	305	7.65	165
165	23	6	43	16	---	15	---	6	215	7.4	167
87	16	6	---	F	---	5	---	6	---	---	168
60	---	6	---	1	9/66	---	3.0	5	178	7.5	170
15	---	36	---	---	---	---	---	1	30	6.5	171
175	81	6	90;173	55	---	12	---	8	---	7.9	172
97	47	6	75;95	18	5/64	30	---	---	---	---	173
97	44	6	---	42	---	22	---	---	---	---	174
73	46	6	70	26	8/65	12	---	8	280	---	175
95	45	6	---	28	---	25	---	8	325	7.6	176
73	46	6	70	35	---	12	---	---	---	---	177
76	35	6	---	2	5/66	5	---	6	260	7.9	178
76	35	6	---	F	---	30	---	6	210	---	180
65	23	6	---	9	---	25	---	4	140	7.8	183
100	47	6	---	25	10/64	15	---	5	240	---	184
150	39	6	---	8	---	15	---	---	---	---	186
100	---	6	---	25	---	10	---	5	200	---	189
34	13	6	32	22	10/69	---	41	---	---	---	190
179	---	6	---	33	10/69	---	200	16	790	8.22	191
29	0	6	21	18	9/69	---	---	---	---	---	192
37	23	6	58	22	10/69	---	11	---	---	---	193
32	26	6	---	23	10/69	---	---	---	---	---	194
35	0	6	12	17	10/69	---	---	---	---	---	195
28	21	6	25	21	10/69	---	---	---	---	---	196
27	31	6	---	8	7/69	---	---	---	---	---	197
37	21	6	---	23	7/69	---	---	---	---	---	198
29	7	6	25	26	7/69	---	---	---	---	---	199
38	21	6	30	4	8/69	---	---	---	---	---	200
26	26	6	30	20	9/69	---	---	---	---	---	201
35	7	6	---	10	9/69	---	---	---	---	---	202
40	0	6	---	27	7/69	---	---	---	---	---	203
---	---	6	---	28	10/69	---	---	---	---	---	204
38	10	6	---	22	9/69	---	---	---	---	---	205
38	11	6	---	23	9/69	---	---	---	---	---	206
35	26	6	26	19	9/69	30	---	---	---	---	207
---	---	6	---	---	---	---	---	---	---	---	208
35	30	6	32;33;34	14	9/69	13	420	---	---	---	209
31	11	6	---	12	9/69	---	---	---	---	---	210
26	21	6	25;32;35	24	9/69	---	---	---	---	---	211
42	13	6	---	14	9/69	---	3.8	---	---	---	212
48	31	6	---	23	9/69	11	280	---	---	---	213
48	9	6	---	17	9/69	---	---	---	---	---	214
51	0	6	49	19	11/69	---	13	---	---	---	215
36	3	6	---	13	9/69	---	---	---	---	---	216
44	14	6	---	20	9/69	---	---	---	---	---	217
48	16	6	44	25	10/69	26	12	---	---	---	218
45	24	6	---	15	9/69	---	---	---	---	---	219
41	23	6	46	39	10/69	---	---	---	---	---	220
52	12	6	---	28	10/69	---	---	---	---	---	221
20	16	6	---	21	10/69	---	---	---	---	---	222
52	12	6	---	17	11/69	---	.04	---	---	---	223
42	8	6	26	14	10/69	---	23	---	---	---	224
23	14	6	22;45	19	10/69	---	---	---	---	---	225
24	---	6	---	16	9/69	---	---	---	---	---	226
45	13	6	31	44	11/69	---	---	---	---	---	227
41	0	6	19;22	15	11/69	---	---	---	---	---	228
23	10	6	19;38;51	17	3/70	---	---	---	---	---	229
20	21	6	24;30;43	15	3/70	8	---	---	---	---	230
15	6	6	40;60	11	3/70	30	---	---	---	---	231
51	15	6	34	17	3/70	---	---	---	---	---	232
59	12	6	22	12	3/70	---	---	---	---	---	233
350	30	6	150;250	58	2/69	15	---	---	---	---	244

TABLE 13.

Well location						Alti- tude of land surface (feet)	Topo- graphic setting	Aquifer/ lithology
Number	Lat-Long	Owner	Driller	Date completed	Use			
Cu-246	4012-7702	T. L. Bricker	Merle L. Gayman	1968	H	432	S	Orr/lsdm
247	4016-7658	Charles Kemberling	Harrisburg's Kohl Bros.	1969	H	445	H	Omac/sh
248	4011-7701	Humane Soc. of Harrisburg	do.	1967	H	435	S	Csg/lsdm
249	4016-7654	W. L. Kemery	do.	1966	H	310	C	Omac/shgw
250	4011-7701	Humane Society	do.	1967	U	460	S	Csg/lsdm
251	4019-7654	Archie Werner	Edsanclay Construction Co.	1967	H	340	C	Omac/shgw
252	4009-7700	Center Square Water Co.	Charles H. Eichelberger	---	P	438	W	Ce/slld
253	4016-7656	Jay Brandt	Edsanclay Construction Co.	1966	H	440	F	Omac/shgw
254	4011-7700	Gulf Oil Co.	---	---	C	470	S	Orr/lsdm
255	4018-7655	L. Liddick	Leon K. Sunday	1967	H	420	W	Omac/sh
256	4011-7700	Gulf Oil Co.	---	---	C	470	S	Osh/lsdm
257	4018-7656	Kenneth Small	Harrisburg's Kohl Bros.	1966	H	425	S	Omac/sh
258	4017-7659	George Davis	do.	1966	H	465	F	Omac/sh
259	4016-7657	J. P. Duhrman	John Thran	1970	H	470	H	Omac/shgw
260	4014-7701	Silver Spring Twp.	Joe Cekovich	1963	U	432	H	Ops/dm
261	4018-7655	Pa. Dept. of Agric.	Harrisburg's Kohl Bros.	1969	H	385	F	Omac/shc
262	4014-7654	West Shore Radiator Works	Charles H. Eichelberger	1968	C	410	F	Oc/ls
263	4018-7655	Pa. Dept. of Agric.	Harrisburg's Kohl Bros.	1969	H	390	F	Omac/sh
264	4014-7655	Hill Theatre	---	1946	A	430	S	Osp/lsdm
265	4016-7655	Harrisburg Nat. Hist. Soc.	Harrisburg's Kohl Bros.	1935	R	425	H	Omac/shgw
266	4013-7652	C. F. Mailey	do.	1951	H	450	S	Omac/sh
267	4017-7659	Cumberland Valley Sch. Dist.	do.	---	T	470	H	Omac/sh
268	4014-7653	Juzi Associates	do.	1970	U	395	F	Osp/lsdm
269	4018-7655	Pa. Dept. of Agric.	---	1929	T	390	F	Omac/shc
270	4010-7700	I. S. Eberly	---	---	H	473	F	Czl/lsds
271	4018-7655	Pa. Dept. of Agric.	---	---	T	395	F	Omac/shc
272	4014-7654	Standard Equipment Co.	---	---	U	400	F	Osp/lsdm
273	4017-7656	F. A. Morrow, Jr.	---	---	H	450	H	Omac/shgw
274	4014-7654	Miller and Miller Inc.	Charles H. Eichelberger	1953	U	440	S	Omac/sh
275	4018-7657	WHP Radio	Harrisburg's Kohl Bros.	1949	C	455	S	Omac/sh
276	4013-7704	M. C. Hempt	---	---	H	429	V	Osp/lsdm
277	4016-7657	E. Pennsboro Twp.	Joe Cekovich	---	R	320	V	Omac/shgw
278	4012-7700	Mechanicsburg Water Co.	Harrisburg's Kohl Bros.	1963	P	429	F	Orr/lsdm
279	4015-7658	Harold Manning	Hubler Well Drilling Co.	1959	H	400	S	Ombl/shc
280	4012-7658	Mohlers Church	---	---	H	420	S	Orr/lsdm
281	4015-7657	Dave Judson	---	1951	H	385	H	Ombl/shc
282	4012-7659	Pa. Dept. of Transp.	---	---	U	430	F	Orr/lsdm
283	4015-7659	R. R. Fittrer	---	---	H	390	S	Ombl/shc
285	4015-7654	WCMB Radio Station	---	---	C	405	S	Ombl/shc
286	4011-7702	Blaine Leib	---	---	H	485	W	Czl/lsdm
287	4013-7655	Pa. St. Correctional Inst.	---	1942	T	372	S	Orr/lsdm
288	4011-7702	Blaine Leib	Alfred H. Hollenbaugh	1962	U	485	W	Czl/lsdm
289	4013-7655	Pa. St. Correctional Inst.	Harrisburg's Kohl Bros.	1963	U	360	V	Orr/lsdm
291	4016-7701	Elmer Crone	---	---	H	400	S	Omac/sh
292	4010-7659	Upper Allen Elem. Sch.	Charles H. Eichelberger	---	T	625	H	Omac/sh
293	4014-7701	Raymond Moyer	---	---	H	392	W	Osp/lsdm
294	4013-7700	Northside Sch.	C. E. Sunday	---	U	422	F	Orr/lsdm
295	4015-7700	Bal Savage	---	1929	H	485	W	Oml/sh
297	4015-7706	Charles Taylor	---	---	P	450	H	Omac/shc
298	4012-7701	Mechanicsburg Sen. High Sch.	Charles H. Eichelberger	1969	U	459	S	Csg/lsdm
299	4016-7703	Cumberland Valley Sch. Dist.	Spahr Farm Supply Co.	1961	T	447	F	Omac/sh
300	4011-7701	Blaine Leib	Joe Cekovich	1970	H	478	W	Czl/lsdm
301	4010-7704	Cumberland Valley Sch. Dist.	Harrisburg's Kohl Bros.	---	T	535	S	Ce/slld
302	4014-7654	Pa. Dept. of Transp.	Joe Cekovich	---	U	395	F	Osp/lsdm
303	4015-7708	Cumberland Valley Sch. Dist.	Harrisburg's Kohl Bros.	---	T	492	H	Omac/sh
304	4014-7654	Kesslers Inc.	---	---	U	400	F	Osp/lsdm
305	4014-7703	Cumberland Valley Sch. Dist.	D. W. Sunday	1954	U	540	W	Oml/sh
306	4012-7704	Locust Point Quarry Inc.	---	1943	H	440	S	Orr/lsdm
307	4014-7703	Cumberland Valley Sch. Dist.	D. W. Sunday	---	U	539	S	Oml/sh
308	4013-7703	Silver Springs Industries Inc.	---	1970	N	440	F	Orr/lsdm
309	4014-7703	Cumberland Valley Sch. Dist.	Harrisburg's Kohl Bros.	1966	U	535	F	Oml/sh
310	4013-7701	J. C. Yorlet	---	1941	S	405	V	Orr/lsdm
311	4014-7703	Cumberland Valley Sch. Dist.	Harrisburg's Kohl Bros.	1966	U	472	S	Osp/lsdm

(CONTINUED)

Total depth below land surface (feet)	Casing Depth (feet)	Casing Diameter (inches)	Depth(s) to water-bearing zone(s) (feet)	Static water level: Depth below land surface (feet)	Static water level: Date measured (mo/yr)	Reported yield (gpm)	Specific capacity (gpm/ft)	Hard-ness (gpg)	Specific conduc-tance (micro-mhos at 25°C)	pH	Well number
400	65	6	292;400	65	9/68	---	---	---	---	---	Cu-246
80	30	6	60;70	4	4/70	---	.67	10	440	7.26	247
300	75	6	180;250	25	12/67	60	---	---	---	---	248
398	26	6	378;390	0	8/66	40	---	15	775	---	249
450	65	6	---	13	5/70	---	.06	16	655	7.70	250
103	36	6	16;30;60	---	---	14	---	8	450	---	251
164	40	6	---	6	9/70	---	1.9	---	---	---	252
82	32	6	22;40;80	10	12/66	12	---	---	---	---	253
348	---	12	---	58	---	---	---	---	---	---	254
99	30	6	80	30	7/67	9	---	17	690	---	255
152	---	12	---	57	---	---	2.0	---	---	---	256
161	---	6	125;161	27	8/66	5	---	4	225	---	257
140	30	6	60;90	45	8/66	7	---	---	420	---	258
199	40	6	---	32	5/70	---	.09	---	---	---	259
285	41	6	---	29	5/70	---	.03	17	650	7.60	260
215	60	8	130;195	20	6/69	---	3.0	---	---	---	261
180	60	6	---	---	---	---	---	21	780	7.20	262
230	30	12	170	170	6/69	---	.31	---	---	---	263
500	---	6	---	---	---	105	---	15	625	7.20	264
199	---	6	---	---	---	---	---	---	410	7.48	265
88	---	6	---	---	---	---	---	4	165	6.82	266
500	---	6	---	29	7/70	---	.25	---	---	---	267
285	55	6	100;280	21	7/70	---	.23	---	---	---	268
55	---	---	---	34	5/70	---	2.6	---	---	---	269
---	---	6	---	32	10/70	---	340	14	600	---	270
52	---	---	---	---	---	27	---	---	---	---	271
78	---	6	---	1	---	---	.03	---	---	---	272
68	---	6	---	34	6/70	---	.18	---	105	7.0	273
196	20	8	---	9	6/70	---	1.6	---	375	6.4	274
60	---	6	---	5	6/70	---	.69	10	420	---	275
66	---	6	---	28	6/70	---	240	---	---	---	276
64	---	6	---	0	5/70	---	.79	6	300	---	277
116	106	6	---	35	7/63	---	25	---	---	---	278
95	23	6	---	33	6/70	---	.40	9	415	---	279
---	---	6	---	21	6/70	---	---	---	---	---	280
154	---	6	---	65	5/70	---	.09	18	980	---	281
172	---	6	---	21	7/70	---	66	10	370	---	282
96	---	6	---	49	6/70	---	.03	21	980	---	283
---	---	---	---	20	5/70	---	.11	18	790	---	285
90	60	6	---	---	---	---	---	---	---	---	286
66	30	6	---	15	---	600	---	13	620	---	287
56	---	6	---	41	5/71	---	.73	---	---	---	288
104	63	12	---	5	9/70	---	340	14	710	---	289
90	---	6	---	24	---	---	.10	8	390	---	291
200	---	6	---	48	8/70	---	.14	5	230	---	292
96	---	6	---	26	7/70	---	17	16	670	7.18	293
64	4	6	---	13	7/70	---	590	---	840	7.60	294
100	20	6	---	21	7/70	---	.42	5	218	7.16	295
122	---	6	88;106	56	5/70	---	.33	14	670	---	297
205	27	6	---	---	---	---	---	---	---	---	298
300	---	6	---	16	7/70	---	1.3	11	450	---	299
92	87	6	---	33	7/70	---	25	13	---	7.82	300
---	---	6	---	55	8/70	---	1200	---	610	---	301
147	---	6	---	6	7/70	---	29	8	370	---	302
---	---	6	---	19	8/70	---	1.4	12	550	---	303
---	---	---	---	30	6/70	---	.03	---	---	---	304
295	---	6	---	16	9/70	80	---	---	---	---	305
120	---	6	---	17	7/70	---	.13	---	650	7.65	306
320	---	6	---	---	---	135	---	7	295	---	307
82	67	6	---	29	7/70	---	14	14	480	---	308
420	45	6	34;60;100;335	26	11/70	---	1.0	6	---	---	309
46	---	6	---	10	7/70	---	56	---	440	---	310
350	40	6	80;200	F	12/66	---	1.7	---	---	---	311

TABLE 13.

Well location: Number	Well location: Lat-Long	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Cu-312	4012-7703	Valley Pride Bakery	---	1960	U	460	F	Orr/lsdm
313	4014-7703	Cumberland Valley Sch. Dist.	---	---	U	540	S	Oml/sh
314	4009-7701	Carroll Builders	Charles H. Eichelberger	1970	H	490	S	Ce/slld
315	4010-7658	Alta Hertzler	---	---	H	560	W	Omac/sh
316	4008-7713	Rockwell	---	---	S	593	S	Ce/slld
318	4010-7703	Allen Dairy Farms Inc.	Harrisburg's Kohl Bros.	1936	H	523	S	Ce/slld
319	4016-7656	Pa. Dept. of Health	Moody Drilling Co., Inc.	1969	S	425	S	Omac/shgw
320	4010-7703	J. B. Scott	---	---	H	490	V	Ce/slld
321	4016-7656	Pa. Dept. of Health	Moody Drilling Co., Inc.	1969	S	430	S	Omac/shgw
322	4006-7711	Kimberly Clark Corp.	Layne-New York Co., Inc.	1969	N	560	F	Ct/ldu
323	4016-7656	Pa. Dept. of Health	Moody Drilling Co., Inc.	1969	V	330	V	Omac/shgw
324	4014-7707	Arrow Oil Co.	Harrisburg's Kohl Bros.	1967	C	445	F	Osp/lsdm
325	4013-7655	Irwins Dairy	do.	1950	N	400	F	Orr/lsdm
326	4013-7709	Daily Express Inc.	Merle L. Gayman	1967	H	451	F	Osp/lsdm
327	4013-7655	Irwins Dairy	Harrisburg's Kohl Bros.	1939	N	400	F	Orr/lsdm
328	4014-7708	Bar-B-Q Tavern	Merle L. Gayman	1967	C	430	H	Oc/ls
329	4004-7729	M. Fahnestock	Eldon E. Funk	---	H	660	S	Ost/ls
330	4011-7709	James Costopoulas	Merle L. Gayman	---	P	510	W	Czl/lsdm
331	4005-7729	M. B. Pugh	Robert H. Westbrook	1965	U	669	H	Orr/lsdm
332	4012-7706	J. F. Freet	Merle L. Gayman	---	H	480	S	Ops/dm
333	4005-7729	M. B. Pugh	Eldon E. Funk	---	H	630	S	Orr/lsdm
334	4011-7705	J. J. Zeigler	C. E. Sunday	---	S	470	W	Csg/lsdm
335	4003-7731	Shippensburg St. Col.	Eldon E. Funk	1969	I	630	W	Orr/lsdm
336	4012-7712	Elwood Johnson	Merle L. Gayman	1967	H	455	F	Oc/ls
337	4003-7731	Shippensburg St. Col.	Eldon E. Funk	1969	F	655	F	Orr/lsdm
338	4011-7709	Samuel Nicholson	Merle L. Gayman	1967	H	535	S	Czl/lsdm
339	4003-7731	Shippensburg St. Col.	Eldon E. Funk	1969	A	653	W	Orr/lsdm
340	4009-7714	L. J. Wolf	Merle L. Gayman	1966	H	549	W	Ost/ls
341	4003-7731	Shippensburg St. Col.	Eldon E. Funk	1970	I	658	W	Orr/lsdm
342	4009-7714	Emma Meyer	Merle L. Gayman	1967	H	550	W	Ost/ls
343	4007-7725	McCoy	---	---	U	622	S	Osh/ls
344	4010-7713	G. E. Love	Merle L. Gayman	1966	H	550	H	Orr/lsdm
345	4007-7726	R. O. Negley	Eldon E. Funk	1967	H	605	H	Orr/lsdm
346	4010-7713	P. F. Orner	Merle L. Gayman	1967	H	520	V	Orr/lsdm
347	4008-7720	Robert Stambaugh	K. R. Whisler	1968	H	598	V	Ce/slld
348	4011-7706	G. W. Hendricks	Merle L. Gayman	1967	H	520	S	Csg/lsdm
349	4005-7719	Ronnie Diehl	K. R. Whisler	1968	H	703	S	Qc/gv
350	4011-7706	Paul Bistline	Merle L. Gayman	1968	H	540	S	Csg/lsdm
351	4005-7719	C. G. Laughman	K. R. Whisler	1967	H	655	S	Qc/cygv
352	4014-7707	Sun Oil Co.	Harrisburg's Kohl Bros.	1966	C	435	W	Osp/lsdm
353	4005-7720	Herman Cockley	K. R. Whisler	1967	H	672	S	Qc/cygv
354	4010-7711	Baish Body Shop	Merle L. Gayman	1966	H	500	S	Csg/lsdm
355	4006-7718	Dan Bucher	Eldon E. Funk	1968	H	635	P	Ct/ldu
356	4011-7709	James Costopoulas	Merle L. Gayman	1968	P	508	W	Czl/lsdm
357	4008-7720	Calvin Tritt	---	---	U	615	S	Czl/lsds
358	4011-7707	Paul Koser	Alfred H. Hollenbaugh	1966	H	501	S	Orr/lsdm
359	4012-7716	Charles Rife	Harrisburg's Kohl Bros.	1930	C	497	V	Orr/lsdm
360	4014-7708	M & B Truck Stop	Merle L. Gayman	1967	C	430	S	Oc/ls
361	4011-7715	Lehman Bear	do.	1967	H	485	S	Orr/lsdm
362	4009-7708	W. Shaw	Lloyd M. Brandt	1967	H	580	S	Ce/slld
363	4011-7716	J. B. Toaster	Merle L. Gayman	1967	H	485	S	Orr/lsdm
364	4011-7712	E. B. Swarner	K. R. Whisler	1967	H	488	W	Orr/lsdm
365	4010-7717	Wayne Burgett	Merle L. Gayman	1971	H	550	H	Orr/lsdm
366	4009-7709	Earl Woods	do.	1966	S	535	W	Ce/slld
367	4010-7717	Darrell Miller	do.	1967	H	552	H	Orr/lsdm
368	4011-7705	W. R. Brehm	do.	1967	H	460	S	Czl/lsdm
369	4011-7717	Howard Eshenour	do.	1966	H	512	F	Orr/lsdm
370	4010-7706	Lester Zeigler	do.	1966	H	550	S	Czl/lsds
371	4012-7715	Gerald Swigert	do.	1970	H	453	V	Orr/lsdm
372	4009-7705	Casey	Harrisburg's Kohl Bros.	1966	H	520	S	Czl/lsdm
373	4012-7717	Humble Oil and Refining Co.	do.	1951	C	492	S	Osp/lsdm
374	4011-7713	E. J. Miller	Leon K. Sunday	1967	H	490	F	Ops/dm
375	4012-7717	Humble Oil and Refining Co.	Harrisburg's Kohl Bros.	1958	C	490	S	Osp/lsdm
376	4011-7713	E. J. Miller	Leon K. Sunday	1967	H	490	F	Ops/dm
377	4011-7717	Lester Keck, Jr.	---	1950	H	510	F	Orr/lsdm
378	4011-7713	John Zaengle	Leon K. Sunday	1967	H	480	F	Orr/lsdm
379	4009-7718	V. C. Holler	Merle L. Gayman	1971	H	575	H	Csg/lsdm
380	4012-7713	K. L. Lay	do.	1966	H	465	F	Orr/lsdm
381	4011-7717	Richard Zimmerman	---	---	U	513	H	Osp/lsdm
382	4012-7713	Jack Henderson	Merle L. Gayman	1966	H	475	F	Orr/lsdm
383	4008-7716	L. B. Phillips	---	---	U	618	S	Czl/lsdm
384	4013-7708	Gulf Oil Co.	Harrisburg's Kohl Bros.	1969	C	450	S	Oc/ls
385	4010-7716	Cumberland Valley Golf Club	do.	---	I	540	W	Orr/lsdm
386	4013-7708	Humble Oil and Refining Co.	do.	1967	C	440	S	Oc/ls
387	4012-7719	N. C. Miller	K. R. Whisler	1967	H	473	F	Osp/lsdm
388	4013-7708	Mrs. R. W. Keller	Merle L. Gayman	1966	H	480	H	Osp/lsdm
389	4012-7719	P. B. Snyder	K. R. Whisler	1967	H	603	S	Oc/ls

(CONTINUED)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hard-ness (gpg)	Specific conduc-tance (micro-mhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
69	21	6	---	46	7/70	---	---	---	---	---	Cu-312
50	50	6	---	29	11/70	---	---	---	---	---	313
93	80	6	---	44	9/70	---	4.1	13	325	---	314
---	---	6	---	12	9/70	---	9.3	7	350	---	315
---	---	---	---	38	3/72	---	---	---	---	---	316
280	60	6	---	63	12/70	---	4.4	---	750	---	318
144	92	6	135	38	9/69	3	---	---	---	---	319
67	---	6	---	43	10/70	---	10	11	540	---	320
129	65	6	74;126	30	9/69	5	---	---	---	---	321
600	327	12	---	78	9/69	---	35	---	---	---	322
31	7	6	24	F	9/69	2	---	---	---	---	323
110	98	6	70;100	20	4/71	---	.20	15	820	7.2	324
200	50	6	---	---	---	50	---	---	---	---	325
140	80	6	110;140	27	4/71	---	19	13	630	7.4	326
275	---	6	---	---	---	25	---	17	1130	---	327
400	119	6	260;320;400	47	4/71	20	---	---	---	---	328
230	20	6	205	---	---	---	---	---	---	---	329
---	---	6	---	40	4/71	---	.09	14	620	7.00	330
335	20	6	---	60	4/71	---	.06	20	860	---	331
75	50	6	---	31	4/71	---	---	21	900	---	332
520	39	6	490	34	4/71	---	.66	13	625	---	333
110	30	6	95	22	4/71	---	.70	19	900	---	334
68	42	8	60	12	6/71	---	33	15	660	7.22	335
250	148	6	190;250	68	4/67	12	---	---	---	---	336
142	39	6	140	35	5/69	50	---	---	---	---	337
370	145	6	255;370	68	5/67	14	---	---	---	---	338
105	60	6	65;72	28	7/71	---	15	14	690	---	339
200	112	6	155;200	48	11/66	12	---	---	---	---	340
105	20	8	67;102	34	7/71	---	---	---	---	---	341
122	48	6	91;122	37	8/67	11	---	---	---	---	342
142	---	---	---	52	4/71	---	.06	---	---	---	343
172	72	6	145;172	48	12/66	10	---	---	---	---	344
290	50	6	250;270	---	---	2	---	---	---	---	345
117	---	6	92;110	55	1/67	15	---	---	---	---	346
75	30	6	40;72	2	5/68	40	---	---	---	---	347
123	94	6	123	36	7/67	18	---	---	---	---	348
84	83	6	---	50	5/68	20	---	---	---	---	349
114	90	6	114	40	9/68	10	---	---	---	---	350
73	72	6	72	37	11/67	15	---	---	---	---	351
178	21	6	118;168	40	10/66	10	---	---	---	---	352
79	78	6	78	60	8/67	20	---	---	---	---	353
460	88	6	180;270;460	52	11/66	20	---	---	---	---	354
68	65	6	65	---	---	---	---	---	---	---	355
420	194	---	365;420	62	8/68	15	---	---	---	---	356
113	---	6	---	84	5/71	18	---	---	---	---	357
50	30	6	42	33	8/66	---	---	---	---	---	358
200	---	6	---	50	9/71	---	---	---	---	---	359
530	153	6	238;362;530	52	4/71	18	---	---	---	---	360
165	42	6	110;165	53	7/71	---	8.5	15	630	---	361
152	68	6	150	98	5/67	---	---	---	---	---	362
145	34	6	110;145	34	6/67	9	---	---	---	---	363
70	8	6	50	30	6/67	24	---	---	---	---	364
182	72	6	---	62	5/71	---	20	14	560	---	365
367	108	6	175;260;367	67	9/66	18	---	---	---	---	366
145	76	6	90;145	38	6/67	8	---	---	---	---	367
423	77	6	192;328	62	5/67	16	---	---	---	---	368
230	43	6	192;230	48	11/66	12	---	18	560	---	369
270	119	6	182;270	72	10/66	10	---	---	---	---	370
100	58	6	---	15	5/71	---	64	15	610	---	371
98	26	6	58;89	45	7/66	40	---	---	---	---	372
200	34	6	---	44	7/71	---	95	---	---	---	373
275	30	6	68;170;260	62	11/67	7	---	---	---	---	374
225	---	6	---	74	9/58	80	---	---	---	---	375
275	28	6	80;135;220	60	11/67	6	---	---	---	---	376
125	30	6	---	46	5/71	---	.72	16	950	---	377
100	30	6	85	40	12/67	12	---	---	---	---	378
600	68	6	---	58	5/71	---	.08	21	850	---	379
148	115	6	105;148	52	9/66	15	---	---	---	---	380
151	---	6	---	33	5/71	---	.1	24	1100	---	381
177	166	6	177	41	12/66	16	---	---	---	---	382
109	---	6	---	88	6/71	---	---	---	---	---	383
258	41	6	110;240	39	5/71	---	.33	---	---	---	384
303	---	6	---	30	9/61	---	1.4	---	---	---	385
300	36	6	95;252	32	5/71	---	.20	---	---	---	386
140	17	6	100;135	23	10/67	7	---	15	630	---	387
400	54	6	180;400	58	8/66	15	---	---	---	---	388
101	23	6	40;97	14	11/67	24	---	15	610	---	389

TABLE 13.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Number	Lat-Long							
Cu-390	4011-7708	Otto Brothers	---	1914	U	503	F	Czl/lsdm
391	4014-7718	P. B. Snyder	K. R. Whisler	1967	H	460	H	Omm/shgw
392	4007-7709	PPG Industries Inc.	Charles H. Eichelberger	1971	N	556	S	Ct/ldu
393	4012-7719	Paul Snyder	---	---	S	452	W	Oc/ls
394	4008-7718	O. A. Kitzmiller	K. R. Whisler	1971	S	670	S	Czl/lsdm
395	4011-7718	George Zimmerman	---	---	U	505	S	Osp/lsdm
396	4007-7711	Mount Holly Springs Bor.	Harrisburg's Kohl Bros.	1956	P	583	S	Ct/ldu
397	4011-7717	George Zimmerman	---	---	U	515	F	Osp/lsdm
398	4007-7711	John Miller	Lloyd M. Brandt	1967	H	562	V	Ct/ldu
399	4012-7718	Gerald Hippel	K. R. Whisler	1969	H	463	S	Oc/ls
400	4007-7711	R. W. Wolfe	Lloyd M. Brandt	1969	H	533	V	Ct/ldu
401	4011-7722	L. H. Kipp	K. R. Whisler	1966	H	492	H	Ombl/shc
402	4007-7711	C. W. Mengle	Lloyd M. Brandt	1967	H	533	V	Ct/ldu
403	4012-7720	Chester Weaver	Charles H. Eichelberger	---	S	485	S	Oc/ls
404	4007-7710	Paul Murtorff	Lloyd M. Brandt	1967	H	540	T	Ct/ldu
405	4011-7721	Walter Fickes	Merle L. Gayman	1966	H	520	W	Osp/lsdm
406	4007-7711	William March	Lloyd M. Brandt	1968	H	563	S	Ct/ldu
407	4011-7721	R. H. Frey	K. R. Whisler	1967	H	510	S	Orr/lsdm
408	4007-7711	Glenn Polm	Merle L. Gayman	1966	H	560	S	Ct/ldu
409	4011-7721	William Houck	K. R. Whisler	1967	H	550	S	Oc/ls
410	4007-7711	Richard Stone	Harrisburg's Kohl Bros.	1968	H	518	V	Qc/cygv
411	4010-7720	Caroll Wickard	Merle L. Gayman	1966	H	510	H	Orr/lsdm
412	4012-7713	William Dyarman	do.	---	S	450	S	Oc/ls
413	4011-7722	Walter Fickes	do.	1967	H	480	W	Oc/ls
414	4012-7714	W. A. George	do.	1966	H	440	S	Osp/lsdm
415	4011-7719	Donald Lehman	---	---	S	485	S	Orr/lsdm
416	4012-7712	Calvin Burr	Merle L. Gayman	1966	H	468	F	Orr/lsdm
417	4010-7721	J. S. Wolff	---	---	U	533	S	Orr/lsdm
418	4010-7706	M. V. McCartney	Harrisburg's Kohl Bros.	1940	H	515	W	Czl/lsds
419	4010-7721	Glenn Lehman	---	---	S	505	W	Orr/lsdm
420	4009-7709	G. J. Westbrook	---	---	S	530	W	Ce/slld
421	4009-7721	D. K. Reid	Eldon E. Funk	1960	U	550	W	Osh/ls
422	4006-7710	Eaton-Dikeman Co.	A. C. Reider & Son, Inc.	1944	U	590	V	Ca/qz
423	4010-7718	Walter Garman	K. R. Whisler	1968	H	510	V	Osh/ls
424	4013-7709	Carlisle Vet. Clinic	Merle L. Gayman	---	C	442	S	Oc/ls
425	4010-7719	Mervin Yinger	---	---	S	525	S	Osp/lsdm
426	4011-7710	Bus. Airport of Carlisle	---	1968	C	500	W	Czl/lsdm
427	4008-7721	Don Mowry	---	1953	C	632	S	Csg/lsdm
428	4010-7709	Seventh Day Adventist Ch.	Joe Cekovich	1965	I	538	H	Czl/lsdm
429	4009-7719	F. G. Chestnut	Merle L. Gayman	1961	S	600	S	Csg/lsdm
430	4009-7717	Hooke & Suter	C. E. Sunday	1970	P	595	H	Csg/lsdm
431	4008-7718	O. A. Kitzmiller	---	---	U	670	H	Czl/lsdm
432	4010-7713	Carlisle Livestock Market Inc.	---	---	C	518	W	Orr/lsdm
433	4010-7718	William McKeehan	---	---	S	505	W	Orr/lsdm
434	4009-7710	Lester Mellott	C. E. Sunday	---	H	518	S	Czl/lsdm
435	4010-7718	W. S. McKeehan	---	---	S	510	S	Orr/lsdm
436	4007-7712	P. L. Dick	---	---	H	525	V	Ct/ldu
437	4009-7720	John Staub	C. E. Sunday	---	S	577	H	Osh/ls
438	4011-7707	Paul Kutz	Merle L. Gayman	---	H	489	F	Orr/lsdm
439	4008-7722	George Stambaugh	---	---	S	630	H	Ost/ls
440	4010-7709	L. S. Tanger	Floyd L. Shreffler	---	H	530	S	Czl/lsdm
441	4008-7719	R. A. Bream	---	---	S	660	W	Czl/lsds
442	4010-7711	Charles McMurray	---	---	H	525	S	Czl/lsds
443	4008-7719	David Hosfeld	---	---	H	655	W	Czl/lsds
444	4009-7712	W. H. Dodd	---	---	H	533	W	Czl/lsds
445	4010-7715	P. E. Wyrick	Leon K. Sunday	---	S	538	S	Osh/ls
446	4009-7714	Carl Downes	---	---	S	590	W	Czl/lsds
447	4009-7716	L. L. Lay	---	---	S	585	W	Csg/lsdm
448	4010-7711	Citgo	---	1949	C	505	W	Csg/lsdm
449	4012-7715	Clark Sheaffer	Merle L. Gayman	1967	H	490	H	Osp/lsdm
450	4010-7706	S. T. Ege	---	---	U	505	W	Czl/lsdm
451	4011-7715	J. E. Clouse	---	---	C	500	W	Orr/lsdm
452	4010-7713	John Hatfield	Leon K. Sunday	1960	U	520	S	Orr/lsdm
453	4010-7715	John Churlick	Merle L. Gayman	---	H	505	F	Orr/lsdm
454	4007-7709	South Middleton Twp.	Moody Drilling Co., Inc.	1971	U	538	S	Ct/dm
455	4009-7715	Luther Mountz, Jr.	---	---	S	515	S	Czl/lsdm
456	4007-7709	South Middleton Twp.	Moody Drilling Co., Inc.	1971	P	540	S	Ct/dm
457	4008-7715	P. J. and S. L. Hoover	---	1934	S	628	H	Ce/slld
458	4012-7711	C. H. Masland and Sons	Harrisburg's Kohl Bros.	1929	U	460	W	Orr/lsdm
459	4007-7717	Glenn Gilbert	---	1960	U	640	S	Ce/slld
460	4012-7711	C. H. Masland and Sons	Charles H. Eichelberger	1965	U	462	F	Osp/lsdm
461	4009-7718	Clarence Coller	C. E. Sunday	1929	U	612	H	Csg/lsdm
462	4010-7711	Bruce Barrick	D. W. Sunday	1954	P	471	W	Czl/lsdm
463	4008-7718	Lewis Fink	Merle L. Gayman	1965	S	615	S	Czl/lsds
464	4010-7711	Bruce Barrick	Floyd F. Blosser	1960	P	473	W	Czl/lsdm

(CONTINUED)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hard-ness (gpg)	Specific conduc-tance (micro-mhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
1000	---	6	---	35	4/72	---	---	---	---	---	Cu-390
85	---	6	82	29	9/67	---	.23	12	295	---	391
164	101	6	---	67	5/71	---	630	5	220	---	392
---	---	6	---	10	7/71	---	6.8	15	710	---	393
418	20	6	110;415	105	5/71	10	---	---	---	---	394
375	---	6	---	41	7/71	---	.07	---	---	---	395
192	152	8	---	97	3/67	---	41	---	---	---	396
184	---	6	---	56	7/71	---	22	20	1300	---	397
142	100	6	140	40	10/67	40	---	---	---	---	398
75	22	6	40;72	23	1/69	24	---	---	630	---	399
84	67	6	84	30	4/69	30	---	---	---	---	400
70	20	6	25;65	28	11/66	24	---	14	620	---	401
67	60	6	66	28	10/67	30	---	---	---	---	402
65	35	6	---	33	7/71	---	1.7	30	950	6.80	403
108	90	6	106	58	10/67	30	---	---	---	---	404
570	---	6	110;520;570	78	7/66	30	---	18	761	---	405
107	82	6	105	60	2/68	30	---	---	---	---	406
170	22	6	54;165	38	7/71	---	.05	16	720	---	407
115	106	6	115	46	5/66	20	---	---	---	---	408
187	21	6	132;177	70	6/67	8	---	15	660	---	409
185	156	6	156	8	11/68	12	---	---	---	---	410
290	113	6	170;290	44	7/71	---	31	20	615	7.20	411
165	119	6	---	37	5/71	60	---	---	---	---	412
275	110	6	165;275	62	8/67	16	---	11	310	---	413
600	143	6	370;575	55	7/66	2	---	---	---	---	414
71	---	6	---	42	7/71	---	25	21	660	7.15	415
390	65	6	185;390	62	10/66	14	---	---	---	---	416
229	---	6	---	49	7/71	---	---	---	---	---	417
50	---	6	---	25	5/71	---	---	---	---	---	418
78	---	6	---	36	7/71	---	---	13	650	---	419
---	---	6	---	56	6/71	---	170	13	660	---	420
110	40	6	---	34	7/71	---	.07	16	700	---	421
563	250	8	---	+35	---	---	.52	---	---	---	422
45	29	6	30;40	10	2/68	36	18	15	550	---	423
177	75	6	---	22	5/71	---	.16	15	625	---	424
210	40	6	---	54	7/71	---	---	18	700	---	425
---	---	6	---	47	6/71	---	9.1	13	550	---	426
400	---	6	---	88	8/71	---	.06	15	550	---	427
191	97	6	---	70	6/71	20	---	15	500	7.3	428
137	---	6	---	23	7/71	---	---	29	1700	7.4	429
393	51	6	70;90;200;300	77	6/71	---	.22	12	850	---	430
200	---	6	---	105	8/71	---	---	---	---	---	431
---	---	6	---	39	6/71	---	36	15	650	---	432
198	---	6	---	49	8/71	---	---	23	810	6.8	433
60	40	6	---	29	6/71	---	180	---	625	---	434
99	---	6	---	18	8/71	---	---	16	650	7.2	435
80	---	6	---	11	6/71	---	3	---	---	---	436
108	---	6	---	51	8/71	---	13	12	475	---	437
217	---	6	---	32	7/71	---	---	---	---	---	438
248	---	6	---	94	8/71	---	---	27	1100	---	439
81	---	6	---	51	7/71	---	17	16	650	---	440
167	---	5	---	---	---	---	---	14	550	---	441
---	---	6	---	57	7/71	---	2	---	---	---	442
190	---	6	---	126	8/71	---	---	---	---	---	443
---	---	6	---	48	7/71	---	.05	---	---	---	444
153	15	6	145	37	8/71	---	14	14	470	---	445
250	---	6	---	46	7/71	---	.03	---	---	---	446
126	---	6	---	43	8/71	---	---	15	590	---	447
92	4	6	---	49	7/71	---	---	---	---	---	448
97	47	6	97	38	7/67	6	---	20	820	---	449
20	---	48	---	F	5/71	---	---	---	---	---	450
94	---	6	---	51	8/71	---	---	22	1300	---	451
170	---	6	---	39	7/71	---	.65	20	900	---	452
65	---	6	---	32	8/71	---	---	17	680	---	453
550	122	8	---	57	8/71	35	---	---	---	---	454
270	---	6	---	33	8/71	---	---	16	610	---	455
205	144	10	169;172;178; 193	52	8/71	---	160	---	---	8.1	456
165	40	6	---	76	8/71	---	3.8	19	720	---	457
203	36	8	---	14	7/71	200	---	---	---	---	458
168	---	6	---	61	8/71	---	---	---	---	---	459
600	29	8	56;70;180; 228;234;262; 323;528	31	7/71	---	8.0	20	720	---	460
215	---	6	---	97	8/71	---	---	---	---	---	461
51	40	6	51	---	---	20	---	---	---	---	462
225	93	6	---	89	8/71	---	1.7	19	725	---	463
63	---	6	---	---	---	60	---	---	---	---	464

TABLE 13.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Number	Lat-Long							
Cu-465	4012-7717	Edward Morrison	Floyd F. Blosser	1956	H	462	S	Oc/ls
466	4009-7724	Hershey Foods Corp.	Harrisburg's Kohl Bros.	1939	N	500	S	Osp/lsdm
467	4012-7716	Russel Mackey	K. R. Whisler	1968	H	450	S	Oc/ls
468	4009-7725	R. F. Nealy	---	---	U	598	H	Oc/ls
469	4012-7716	C. R. Mackey	Floyd L. Shreffler	---	H	458	S	Oc/ls
470	4010-7724	E. E. Kough Sons	Merle L. Gayman	---	S	550	S	Oml/sh
471	4012-7715	W. L. Wilks	do.	1966	H	478	S	Osp/lsdm
472	4010-7724	E. E. Kough Sons	---	---	U	530	S	Oc/ls
473	4007-7716	W. M. Jones	---	---	S	611	S	Ce/slld
474	4008-7725	S. H. Cohick	---	---	S	585	S	Oc/ls
475	4010-7715	Chester Weibley	Merle L. Gayman	1966	H	505	F	Orr/lsdm
476	4008-7726	Clarence Kuhns	---	1953	H	565	F	Osp/lsdm
477	4008-7722	Harold Minnich	Merle L. Gayman	1965	H	564	V	Orr/lsdm
478	4008-7725	Paul Gross	---	---	H	573	S	Ops/dm
479	4007-7720	Kenneth Gettle	Lloyd M. Brandt	1967	H	635	W	Ce/slld
480	4006-7724	Mennonite Christian Brotherhood	Eldon E. Funk	1971	H	610	V	Csg/lsdm
481	4008-7721	Robert Sokalaski	Merle L. Gayman	1968	H	665	H	Czl/lsds
482	4008-7724	R. R. Zinn	K. R. Whisler	1954	S	532	W	Ops/dm
483	4007-7721	Nora Harman	---	---	H	695	H	Czl/lsds
484	4009-7723	O. T. McCullough	---	1926	H	580	S	Orr/lsdm
485	4006-7719	Robert Duprey	Eldon E. Funk	1968	H	695	W	Cwb/slld
486	4008-7723	Charles Heckendorn	---	---	H	595	F	Orr/lsdm
487	4005-7720	H. L. Long	Eldon E. Funk	1969	H	682	W	Ct/ldu
488	4009-7726	John Hostetter	Merle L. Gayman	1967	U	538	S	Oc/ls
489	4007-7718	John McKehan	---	---	U	660	S	Ce/slld
490	4008-7727	P. O. Oyarman	---	1961	H	562	S	Osp/lsdm
491	4009-7718	J. Hogan	---	---	U	540	S	Osh/ls
492	4003-7727	Leroy Kipe	---	1964	U	790	S	Czl/lsds
493	4006-7721	Raymond Watson	Eldon E. Funk	1967	H	705	F	Cwb/ldss
494	4007-7723	S. L. Spencer	Harrisburg's Kohl Bros.	1938	H	665	S	Czl/lsdm
495	4011-7716	Peter Kutulakis	---	---	S	510	S	Orr/lsdm
496	4007-7728	G. C. Myers	Harrisburg's Kohl Bros.	1956	S	583	H	Osp/lsdm
497	4007-7717	John Bucher	Charles H. Eichelberger	1970	S	628	S	Ce/slld
498	4005-7727	Valley Quarries Inc.	G. Edgar Harr Sons' Corp.	---	N	633	S	Ost/ls
500	4007-7724	Pa. Fish Comm.	Eldon E. Funk	1971	C	540	S	Csg/lsdm
501	4006-7720	Hi-Way Pipe Co.	Harrisburg's Kohl Bros.	---	N	636	V	Cwb/ldss
502	4006-7728	F. W. Davison	---	---	H	589	V	Osp/lsdm
503	4007-7717	Ralph Richwine, Jr.	---	---	H	660	H	Ce/slld
504	4007-7724	Pa. Fish Comm.	Joe Cekovich	1970	H	524	S	Csg/lsdm
505	4007-7718	P. R. Whistler	---	---	H	662	S	Cwb/ldss
506	4007-7725	Harper Hershey	Eldon E. Funk	1970	H	640	H	Osh/ls
507	4006-7717	Charles Cohick	---	---	H	650	H	Cwb/ldss
508	4006-7725	Harper Hershey	Haskins	---	H	673	H	Czl/lsdm
509	4006-7717	Preston Dick	---	1953	U	592	V	Qc/sdgv
510	4005-7727	J. A. Strohm	Eldon E. Funk	1967	H	680	H	Csg/lsdm
511	4006-7717	L. B. Phillips	Merle L. Gayman	---	R	615	S	Cwb/ldss
512	4007-7723	George Stambaugh	Eldon E. Funk	---	H	630	S	Czl/lsdm
513	4006-7720	Penn Twp. Con. Sch.	do.	---	T	695	F	Cwb/ldss
514	4006-7723	Bruce Martin	do.	1971	H	730	S	Ce/slld
515	4007-7715	David Lilich	---	---	H	565	S	Cwb/ldss
516	4006-7724	Clarence Holtry, Sr.	Eldon E. Funk	1967	S	678	S	Ce/slld
517	4006-7715	Raudabaugh Estate	---	---	H	579	S	Ct/ldu
518	4005-7724	Jacksonville Sch.	---	---	I	733	V	Cwb/ldss
519	4006-7717	William Dreisbach	Charles H. Eichelberger	1966	P	607	V	Qc/sdgv
520	4005-7726	G. W. Koser	do.	1968	S	648	V	Csg/lsdm
521	4007-7722	W. J. Short	---	---	H	640	V	Czl/lsdm
522	4005-7723	Mark Killian	Eldon E. Funk	1966	S	700	S	Cwb/ldss
523	4007-7721	Ronald Shughart	---	---	S	710	S	Czl/lsdm
524	4004-7723	Mark Cockley	Eldon E. Funk	1967	H	750	S	Ct/ldu
525	4006-7721	J. H. Coover	Carl Shoeman	---	S	678	W	Cwb/ldss
526	4004-7725	Robinson Fruit Farm	Eldon E. Funk	1969	H	780	S	Ce/slld
527	4005-7722	M. M. Reichard	do.	1965	S	669	S	Cwb/ldss
528	4006-7723	Eugene Cromer	---	---	U	795	H	Ce/slld
529	4006-7722	Herman Reese	---	---	S	695	H	Ce/slld
530	4005-7722	Jane Goodhart	---	---	U	683	W	Ce/slld
531	4006-7722	G. T. Bennet	---	---	H	720	S	Ce/slld
532	4003-7729	News-Chronicle	---	---	U	695	S	Csg/lsdm
533	4005-7722	Edith Meck	Eldon E. Funk	1970	H	669	W	Cwb/ldss
534	4006-7723	Harry Moody	---	---	S	710	S	Ce/slld
535	4002-7731	W. A. Myers	Eldon E. Funk	1966	I	651	F	Osh/ls
536	4005-7724	Harry Halter	---	1963	H	745	S	Ce/slld
537	4009-7713	A. G. Kennish	---	---	H	592	H	Czl/lsds
538	4003-7728	Richard Commerer	Harrisburg's Kohl Bros.	1966	H	760	W	Czl/lsdm
539	4008-7713	F. R. Olson	---	---	H	595	W	Ce/slld
540	4004-7724	Leonard Brumbaugh	Eldon E. Funk	1966	H	785	S	Cwb/ldss
541	4008-7713	Mrs. J. F. Wilson	Gillow	---	H	625	H	Ce/slld
542	4005-7726	Leslie Bockh	---	---	H	760	H	Czl/lsdm
543	4008-7713	Wilson Paving Co.	Gillow	---	C	610	S	Ce/slld
544	4005-7724	John Pattison	Eldon E. Funk	1967	H	738	S	Ce/ls
545	4008-7712	James Touloumes	---	---	H	602	S	Ce/slld
546	4004-7726	---	---	---	H	787	S	Ce/slld

(CONTINUED)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
83	15	6	---	25	8/71	---	---	15	660	---	Cu-465
450	---	8	---	35	11/58	---	1.2	---	---	---	466
82	16	6	40;78	1	1/68	24	---	19	800	---	467
141	---	6	---	28	8/71	---	.09	45	1800	---	468
160	20	6	---	25	8/71	---	---	---	730	---	469
97	40	6	---	10	8/71	---	---	---	---	---	470
173	110	6	170	46	12/66	15	---	---	---	---	471
121	30	6	---	16	4/72	---	---	---	---	---	472
212	---	6	---	49	8/71	---	---	14	550	---	473
730	---	6	---	---	---	---	---	21	1050	6.5	474
85	63	6	85	32	8/66	12	---	---	---	---	475
320	5	6	---	63	8/71	---	.04	17	700	---	476
186	130	6	20;120	60	8/71	---	3.0	14	575	7.07	477
128	124	6	---	64	8/71	---	.09	17	750	---	478
295	41	6	165;295	87	8/71	480	---	14	525	---	479
292	40	6	---	23	8/71	2	---	---	---	---	480
225	175	6	195;225	78	12/68	15	---	15	560	---	481
97	42	6	---	38	8/71	---	66	17	520	7.2	482
400	---	6	---	114	8/71	---	---	13	475	---	483
231	---	6	231	80	8/70	---	.75	24	800	6.2	484
52	38	6	50	---	---	---	---	13	605	---	485
180	---	6	---	90	8/71	---	.83	19	1050	---	486
177	101	6	160;170	---	---	---	---	3	185	---	487
475	58	6	---	35	8/71	---	.08	20	800	---	488
84	40	6	---	42	9/71	---	---	16	650	---	489
130	12	6	---	---	---	---	.48	14	750	---	490
---	---	6	---	30	9/71	---	---	---	---	---	491
150	100	6	---	132	11/71	---	---	---	---	---	492
155	47	6	110;145	35	1/67	---	---	19	775	---	493
204	42	6	---	120	8/71	---	3.4	11	800	---	494
90	---	6	---	63	9/71	---	3.0	17	650	---	495
147	75	6	---	48	9/71	---	---	18	700	---	496
61	40	6	---	12	9/71	---	1.0	17	690	---	497
360	---	6	---	77	9/71	---	---	19	900	---	498
89	---	6	---	13	9/71	---	41	9	540	---	500
205	---	6	---	9	9/71	---	2.6	14	500	---	501
---	---	6	---	39	9/71	---	---	16	625	---	502
---	---	6	---	70	9/71	---	---	11	440	---	503
44	21	6	---	13	9/71	---	---	---	---	---	504
217	---	6	---	30	9/71	---	.07	19	790	---	505
265	130	6	---	97	9/71	---	.19	22	900	---	506
50	---	---	---	44	9/71	---	---	12	500	---	507
210	---	6	---	84	9/71	---	.41	20	800	---	508
40	40	6	---	7	9/71	---	.42	4	195	---	509
230	---	6	---	89	9/71	---	2.2	15	625	---	510
103	65	6	---	20	10/71	50	---	14	380	---	511
292	95	6	210;285	76	9/71	---	1.3	---	---	---	512
516	40	6	---	31	9/71	---	---	---	---	---	513
245	21	6	---	49	9/71	---	.04	16	695	---	514
39	10	6	---	7	9/71	---	---	13	500	---	515
287	---	6	---	68	9/71	---	.03	---	---	---	516
80	---	6	---	19	9/71	---	---	7	305	---	517
90	---	---	---	39	---	---	27	---	---	---	518
41	40	6	---	15	---	---	14	7	270	6.75	519
160	62	6	145;155	54	9/71	---	4.4	11	400	---	520
92	---	---	---	44	9/71	---	---	13	540	---	521
75	---	6	---	35	10/71	---	---	---	---	---	522
210	---	6	---	89	9/71	---	.05	16	750	---	523
160	100	6	---	85	10/71	---	---	---	---	---	524
50	22	6	---	8	9/71	---	8.8	15	620	---	525
310	210	6	---	79	10/71	---	1.3	11	500	---	526
75	32	6	40;65	9	---	---	---	15	610	---	527
450	---	6	---	143	10/71	---	---	---	---	---	528
110	---	6	---	66	9/71	---	---	13	550	---	529
53	---	6	---	7	10/71	---	---	---	---	---	530
---	---	6	---	47	9/71	---	---	---	---	---	531
200	---	6	---	54	10/71	---	---	---	---	---	532
82	38	6	65;78	6	9/71	10	---	17	690	---	533
126	---	6	---	74	10/71	---	---	---	---	---	534
30	20	6	25;30	3	10/71	---	---	21	1100	---	535
223	15	6	---	106	10/71	---	---	---	---	---	536
400	---	6	---	105	9/71	3	---	16	625	---	537
236	203	4	---	109	10/71	---	1.0	13	575	---	538
110	---	---	---	88	9/71	---	---	11	465	---	539
107	84	6	100	51	10/71	---	---	3	75	---	540
135	---	6	---	78	9/71	---	---	---	---	---	541
190	---	4	---	155	10/71	---	.44	---	---	---	542
175	---	6	---	58	9/71	---	.19	15	550	---	543
97	40	6	---	50	10/71	---	---	---	---	---	544
88	---	6	---	60	9/71	---	400	14	660	---	545
143	---	6	---	78	10/71	---	---	---	---	---	546

TABLE 13.

Well location Number	Well location Lat-Long	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/lithology
Cu-547	4011-7714	Rocky Meadows Golf Course	---	---	I	508	F	Orr/lsdm
548	4004-7727	J. H. Holtry	---	---	S	740	W	Czl/lsdm
549	4010-7714	W. R. Stubbs	Merle L. Gayman	1968	S	560	S	Orr/lsdm
550	4003-7729	Chronicle News	Eldon E. Funk	1967	C	695	S	Csg/lsdm
551	4007-7714	George Green	---	---	H	610	F	Cwb/ldss
552	4004-7728	Jacob Oberholtzer	---	---	S	690	H	Czl/lsdm
553	4008-7711	G. H. Searight	---	---	S	563	S	Ce/slld
554	4004-7727	H. E. Piper	Leon K. Sunday	1966	H	795	W	Czl/lsds
555	4009-7711	David Masland	Eldon E. Funk	1968	H	605	H	Czl/lsds
556	4004-7726	Glenn Smith	do.	1968	H	783	S	Czl/lsds
557	4008-7709	Paul Chronister	---	---	S	512	S	Ce/slld
558	4002-7727	William Gilbert	Eldon E. Funk	1967	H	790	S	Cwb/ldss
559	4007-7714	L. W. Lebo	---	---	S	592	F	Cwb/ldss
560	4003-7729	Erma Mansberger	Eldon E. Funk	1967	H	672	V	Czl/lsdm
562	4014-7656	Hampden Twp.	Joe Cekovich	1971	U	410	F	Orr/lsdm
563	4010-7707	O. E. Mentzer	Alfred H. Hollenbaugh	1967	S	520	F	Ce/slld
564	4014-7657	Hampden Twp.	Joe Cekovich	1971	U	418	F	Orr/lsdm
565	4011-7707	Marie Wheeler	---	---	S	541	S	Csg/lsdm
566	4002-7727	John Strayer	Eldon E. Funk	---	H	850	S	Cwb/lsds
567	4012-7709	James Paviol	---	---	C	505	H	Csg/lsdm
568	4003-7729	Simon Alleman	Eldon E. Funk	1966	H	690	V	Czl/lsdm
569	4013-7707	Fibrous Glass Prods.	Merle L. Gayman	1970	C	439	W	Osp/lsdm
570	4003-7728	R. L. Brown	K. R. Whisler	1966	H	720	S	Qc/gv
571	4012-7708	Curtis Stover	---	---	H	490	S	Czl/lsdm
572	4005-7724	Glenn Stouffer	Eldon E. Funk	1968	H	725	F	Ce/ldss
573	4012-7708	Bertha Hull	Aaron Mountz	---	H	482	W	Csg/lsdm
574	4007-7725	McCoy	Eldon E. Funk	1968	H	618	S	Osh/ls
575	4014-7706	Lester Stone, Jr.	---	---	H	464	H	Oml/sh
576	4007-7724	Robert Lindsay	Eldon E. Funk	1968	H	540	W	Osh/ls
577	4015-7704	Harvey Sunday	---	---	U	415	H	Oc/ls
578	4007-7725	Glenn Varner	Merle L. Gayman	1967	H	610	W	Ost/ls
579	4015-7705	F. M. and T. Scrignoli	Leon K. Sunday	1971	H	460	H	Oml/sh
580	4003-7726	Wayne Baker	Eldon E. Funk	1966	U	840	H	Ce/slld
581	4013-7706	R. J. Leiby	C. E. Sunday	---	P	440	S	Osp/lsdm
582	4007-7726	Raymond Negley	K. R. Whisler	1967	H	600	H	Orr/lsdm
583	4006-7731	Amos Funk	Eldon E. Funk	1968	S	647	S	Ombl/shc
584	4003-7729	Ezra Karper	do.	1966	H	710	S	Czl/lsdm
585	4004-7731	F. Foglesanger	do.	1966	S	619	V	Orr/lsdm
586	4005-7724	Harold Bowers	do.	1966	H	745	S	Ce/ldss
587	4013-7705	Roadway Truck Stop	---	---	H	455	F	Osp/lsdm
588	4005-7724	Norman Hemminger	K. R. Whisler	1967	H	729	S	Qc/cygv
589	4003-7730	Paul Hornbaker	Eldon E. Funk	1968	S	649	W	Orr/lsdm
590	4001-7729	Harry Reese	do.	1967	H	782	S	Ce/slld
591	4005-7730	Clifford Pilgrim	---	---	S	603	S	Osp/lsdm
592	4001-7729	H. T. Black	Eldon E. Funk	1969	H	780	F	Ce/slld
593	4004-7731	David Gephart	---	---	S	642	F	Osp/lsdm
594	4001-7729	Clyde Rotz	K. R. Whisler	1967	H	782	S	Qc/cygv
595	4005-7732	Kenneth Hale	Eldon E. Funk	1970	S	615	S	Osp/lsdm
596	4001-7729	M. O. Rockwell	K. R. Whisler	1967	H	785	S	Qc/cygv
597	4005-7731	Louis Barnmont	---	---	S	645	F	Osp/lsdm
598	4001-7729	Harry Doyle	---	1971	H	785	S	Qc/cygv
599	4005-7731	Charles Wenger	---	1958	H	619	F	Osp/lsdm
600	4001-7729	W. McCulloch	---	1966	H	810	S	Qc/gv
601	4004-7730	Jerrald Gayman	---	---	S	670	S	Orr/lsdm
602	4006-7729	Paul Friese	---	---	U	632	S	Oml/sh
603	4003-7730	Irwin Keefer	Merle L. Gayman	1968	H	690	S	Csg/lsdm
604	4001-7729	Ross McCoy	Eldon E. Funk	1968	H	838	S	Ct/ldu
605	4002-7730	J. L. Thrush	do.	---	S	765	S	Ce/slld
606	4005-7725	Lee Matthews	K. R. Whisler	1966	H	730	F	Qc/gv
607	4004-7732	Harold Kauffman	Merle L. Gayman	1965	I	630	H	Osp/lsdm
608	4006-7725	Harold Ninninger	Eldon E. Funk	1967	H	680	S	Czl/lsdm
609	4001-7730	Jack Mayo	---	---	H	750	S	Qc/cygv
610	4002-7726	R. C. Bender	K. R. Whisler	1966	H	830	S	Cwb/ldss
611	4006-7729	Harry Bard	---	---	S	599	F	Orr/lsdm
612	4001-7729	Thomas Smyth	Eldon E. Funk	1966	H	768	V	Ce/slld
613	4003-7730	Roy Burkholder	do.	1966	I	710	W	Czl/lsdm
614	4001-7729	William Russell	do.	1968	H	784	S	Qc/cygv
615	4003-7731	Hershey Chocolate Corp.	Harrisburg's Kohl Bros.	1961	N	645	V	Orr/lsdm
616	4003-7729	J. F. Jones	John L. Butts	1966	H	697	V	Czl/lsdm
617	4004-7732	James Means	---	---	S	642	H	Osp/lsdm
618	4002-7728	Guy Johnson	Ralph E. Robison	1962	H	758	S	Ce/slld
619	4005-7732	Ray Stine	Eldon E. Funk	1967	H	640	S	Oml/sh
620	4010-7722	Orville Heisey	---	---	S	565	H	Ombl/shc
621	4010-7722	Arthur Rife	K. R. Whisler	1968	H	570	S	Oml/sh
622	4010-7724	Kough Quarry	---	---	U	510	S	Oc/lsdm
623	4011-7724	Dallas Hoover	K. R. Whisler	1967	H	505	S	Oml/sh
624	4009-7727	Jack Hockenberry	Eldon E. Funk	1968	H	540	S	Oml/sh
625	4009-7725	Paul Finkenbinder	---	---	S	558	F	Osp/lsdm
626	4008-7726	Nedwell Anderson	---	---	H	565	F	Osp/lsdm
627	4004-7729	C. L. Smith	---	---	S	681	H	Orr/lsdm
628	4003-7728	J. M. Hershey	---	---	H	750	S	Czl/lsdm

(CONTINUED)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
520	200	8	---	49	9/71	300	---	17	725	---	Cu-547
---	---	6	---	129	10/71	---	---	---	---	---	548
125	---	6	---	69	9/71	---	8.5	15	730	---	549
115	51	6	112	---	---	---	---	---	---	---	550
65	---	---	---	55	9/71	---	---	14	575	---	551
146	---	6	---	73	10/71	---	---	---	---	---	552
120	---	6	---	41	9/71	---	.14	17	630	---	553
300	20	---	---	146	10/71	---	---	---	---	---	554
217	71	6	215	133	9/71	---	---	16	620	---	555
173	54	6	135;160	85	10/71	---	---	---	---	---	556
63	---	6	---	42	9/71	---	---	11	450	---	557
165	164	6	---	50	10/71	---	---	6	260	---	558
80	---	---	---	42	9/71	---	---	19	800	---	559
137	23	6	135	19	10/71	---	---	8	360	---	560
100	---	8	---	16	10/71	---	8.7	12	600	---	562
60	---	6	---	36	10/71	---	---	11	550	---	563
148	20	8	---	25	10/71	---	13	14	675	---	564
190	---	6	---	53	10/71	---	---	12	510	---	565
145	140	6	140	---	---	---	---	1	65	---	566
---	---	6	---	54	10/71	---	---	14	620	---	567
153	60	6	90;145	---	---	---	---	8	290	---	568
---	---	6	---	16	10/71	---	---	14	620	---	569
90	66	6	84	77	12/66	15	---	---	---	---	570
---	---	6	---	36	10/71	---	---	---	660	---	571
68	60	---	66	---	---	---	---	14	750	---	572
74	---	6	---	40	10/71	---	---	12	550	---	573
240	20	6	200;235	---	---	---	---	---	---	---	574
120	---	6	---	15	10/71	---	---	11	485	---	575
72	58	6	65;70	---	---	---	---	---	---	---	576
160	---	6	---	38	10/71	---	---	22	940	---	577
400	60	6	265;400	62	1/67	8	---	---	---	---	578
218	---	6	---	28	10/71	---	---	---	---	---	579
245	34	6	243	---	---	---	---	---	---	---	580
150	---	6	---	78	10/71	40	---	---	---	---	581
79	29	6	78	40	3/67	20	---	---	---	---	582
100	31	6	65;80;95	12	10/71	---	.91	12	550	---	583
190	83	6	185	---	---	---	---	---	---	---	584
55	26	6	45;50	20	10/71	---	---	22	880	---	585
85	25	6	80	---	---	---	---	---	---	---	586
---	---	6	---	59	10/71	---	320	20	950	---	587
77	75	6	77	45	8/67	20	---	---	---	---	588
307	20	6	210;304	27	10/71	---	.12	13	550	---	589
160	85	6	150	---	---	---	---	---	---	---	590
65	---	5	---	48	10/71	---	---	14	575	---	591
127	80	6	120	---	---	---	---	---	---	---	592
166	53	6	---	52	10/71	---	---	17	630	---	593
82	75	6	82	47	8/67	21	---	----	---	---	594
155	54	6	140	61	10/71	---	160	15	655	---	595
77	77	6	77	47	8/67	21	---	---	---	---	596
80	---	5	---	63	10/71	---	1.7	15	580	---	597
---	---	6	---	33	11/71	---	---	---	---	---	598
87	---	6	---	51	10/71	---	1.0	19	960	---	599
126	123	6	95	64	11/71	30	---	---	---	---	600
---	---	6	---	52	10/71	---	---	13	560	---	601
21	---	72	---	3	10/71	---	---	---	---	---	602
170	67	6	120	52	10/68	12	---	---	---	---	603
235	225	6	230	99	11/71	---	.56	4	100	---	604
110	80	6	---	27	10/71	---	32	6	245	---	605
88	88	6	88	73	12/66	15	---	---	---	---	606
295	---	6	---	43	10/71	---	---	14	560	---	607
350	7	6	275;310	---	---	---	---	---	---	---	608
20	---	---	---	14	10/71	---	---	24	1200	---	609
155	---	6	150	125	12/66	15	---	---	---	---	610
58	---	6	---	48	10/71	---	---	16	635	---	611
125	51	6	105;120	65	6/66	---	---	---	---	---	612
150	80	6	145	---	---	---	---	10	425	---	613
127	126	6	127	---	---	---	---	---	---	---	614
300	140	6	---	8	1/61	---	2.6	16	725	---	615
104	35	6	30;100	24	11/71	10	---	---	---	---	616
200	---	6	---	66	10/71	---	---	17	875	---	617
183	75	6	---	52	11/71	---	---	---	---	---	618
100	---	6	30;70	7	10/71	---	---	7	365	---	619
22	---	---	---	3	11/71	---	---	19	750	---	620
80	25	6	55;75	24	10/68	20	---	7	300	---	621
250	---	6	---	14	11/71	---	---	---	---	---	622
60	18	6	38	10	11/67	40	---	5	212	---	623
132	20	6	110;122	---	---	---	---	7	300	---	624
96	---	6	---	44	11/71	---	---	20	850	---	625
---	---	6	---	44	11/71	---	---	---	---	---	626
70	---	6	---	56	11/71	---	---	13	575	---	627
150	80	6	145	82	11/71	---	14	8	300	---	628

TABLE 13.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/lithology
Number	Lat-Long							
Cu-629	4009-7705	Blaine Wickard	---	---	S	543	H	Czl/lsds
630	4004-7724	Stanley Coons	York Drilling Co., Inc.	1965	H	772	S	Cwb/ldss
631	4009-7704	Dale Spangler	---	---	S	511	H	Ce/slld
632	4003-7727	Leroy Kipe	Eldon E. Funk	1967	H	790	S	Czl/lsds
633	4009-7702	Harold Hertzler	Charles H. Eichelberger	1964	S	482	S	Ce/slld
634	4003-7724	F. F. Froelich	---	1929	H	840	H	Cwb/ldss
635	4008-7705	P. W. Chronister	Harrisburg's Kohl Bros.	1946	S	468	W	Ce/slld
636	4008-7709	O. O. Stoner	---	---	H	500	S	Ce/slld
637	4012-7705	W. E. Biddle	C. E. Sunday	1970	S	435	S	Osp/lsdm
638	4007-7708	T. M. Shaw	---	---	H	532	S	Qc/cygv
639	4012-7705	W. E. Biddle	---	---	U	440	S	Osp/lsdm
640	4008-7708	Dickinson Col.	Harrisburg's Kohl Bros.	1966	S	510	S	Ce/slld
641	4012-7706	Harold Aikey	---	---	U	475	S	Orr/lsdm
642	4008-7709	F. H. Belt	Charles H. Eichelberger	1971	H	497	S	Ce/slld
643	4011-7702	Wayne Witter	---	1954	H	505	W	Czl/lsds
644	4008-7706	Stanley Brymesser	Merle L. Gayman	1966	H	495	S	Ce/slld
645	4009-7701	Henry Thornton	Charles H. Eichelberger	1970	B	463	S	Ce/slld
646	4008-7706	James Brymesser	---	---	S	510	H	Ce/slld
647	4010-7701	Frank Stoner, Sr.	---	---	S	482	W	Ce/lsds
648	4009-7706	Allenberry Inc.	Spahr Farm Supply Co.	---	H	505	S	Ce/slld
649	4011-7704	William Crain	Harrisburg's Kohl Bros.	1964	S	491	H	Czl/lsdm
650	4012-7658	Suburban Roofing Co.	---	---	H	443	F	Orr/lsdm
651	4013-7700	R. G. Shaull	Spahr Farm Supply Co.	---	H	414	S	Osp/lsdm
653	4014-7702	L. R. Leinaweaver	---	---	S	423	S	Osp/lsdm
655	4010-7705	Lloyd Knistly	---	---	S	530	W	Czl/lsds
657	4010-7706	Glenn Smith	Spahr Farm Supply Co.	1955	S	492	S	Czl/lsds
658	4007-7710	Hempt Brothers	Harrisburg's Kohl Bros.	---	N	518	V	Ct/ldu
659	4012-7705	W. E. Biddle	---	---	H	440	S	Ops/dm
660	4007-7712	McCoy Brothers	Harrisburg's Kohl Bros.	1969	P	523	V	Ct/ldu
661	4012-7702	Mrs. Coover	---	---	U	440	F	Orr/lsdm
662	4018-7656	Summerdale Water Co.	Harrisburg's Kohl Bros.	---	P	500	S	Omac/sh
663	4011-7700	Creedin Paulus	---	---	H	460	F	Csg/lsdm
664	4010-7711	Carlisle Swim Club Inc.	Harrisburg's Kohl Bros.	1958	R	---	W	Orr/lsdm
665	4013-7706	R. L. Coover	Robert H. Westbrook	1967	S	482	F	Osp/lsdm
666	4010-7718	J. L. Kramer	K. R. Whisler	1966	H	530	S	Orr/lsdm
667	4010-7702	Louis Marchi	---	---	H	492	S	Czl/lsdm
668	4001-7727	Richard Luhrs	Eldon E. Funk	1972	H	933	P	Ct/ldu
669	4010-7706	Richard Baldwin	---	---	H	555	F	Ce/slld
670	4004-7723	R. E. Diller	---	---	H	830	S	Ct/ldu
671	4009-7707	Paul Strayer	---	---	H	520	S	Ce/slld
672	4005-7723	Walnut Bottom Rod and Gun Club	---	---	R	682	V	Cwb/ldss
673	4003-7731	Shippensburg St. Col.	Eldon E. Funk	1972	I	644	S	Orr/lsdm
674	4003-7731	do.	do.	1972	I	635	V	Orr/lsdm
675	4003-7731	do.	do.	1972	I	670	S	Orr/lsdm
676	4010-7703	U. S. Geol. Survey	do.	1972	U	532	F	Ce/slld
677	4007-7712	do.	do.	1972	U	586	S	Ct/ldu
678	4007-7712	J. P. Eichelberger	do.	1972	H	603	S	Ct/ldu
679	4014-7701	Rodger Hoke	Spahr Farm Supply Co.	1960	H	410	F	Orr/lsdm
680	4001-7730	Jack Mayo	Eldon E. Funk	1972	H	748	S	Ce/slld
681	4010-7658	Garret	---	---	H	438	S	Oe/ls
682	4014-7701	U. S. Geol. Survey	Eldon E. Funk	1973	U	418	W	Orr/lsdm
683	4014-7717	George Crull	Merle L. Gayman	1966	H	570	S	Oml/sh
684	4014-7718	F. P. Yarlett	K. R. Whisler	1967	H	585	W	Omm/shgw
685	4009-7735	Joseph Hoover	do.	1966	H	623	W	Omu/shss
686	4009-7736	J. W. Russel	Eldon E. Funk	1966	H	762	S	Omu/shss
687	4009-7736	McKinney Church	do.	1967	H	745	S	Omu/shss
688	4008-7732	Erby Weller	---	---	H	560	S	Omu/shss
689	4010-7732	Cirino Machi	Eldon E. Funk	1968	H	645	S	Omu/shss
690	4013-7723	Andrew Bonnie	K. R. Whisler	---	H	645	S	Omm/shgw
691	4010-7733	Lee Gardner	do.	1968	H	705	S	Omu/shss
692	4013-7722	James Arnold	Merle L. Gayman	1967	H	578	S	Omu/shss
693	4009-7736	Humble Oil and Ref. Co.	Harrisburg's Kohl Bros.	1954	C	830	S	Omu/shss
694	4012-7724	William Brownawell	K. R. Whisler	1967	H	602	H	Omm/shgw
695	4009-7736	Humble Oil and Ref. Co.	Harrisburg's Kohl Bros.	1955	C	820	S	Omu/shss
696	4014-7724	George Heberlig	K. R. Whisler	1967	H	590	V	Omu/shss
697	4009-7736	Humble Oil and Ref. Co.	Harrisburg's Kohl Bros.	1958	C	820	S	Omu/shss
698	4007-7731	Boyd Hey	Eldon E. Funk	1966	H	600	H	Oml/sh
699	4013-7717	Donald Chestnut	Merle L. Gayman	1968	H	550	S	Oml/sh
700	4012-7722	St. Peters Ch.	K. R. Whisler	1966	H	612	S	Omm/shgw
701	4013-7718	John Hinkle	Merle L. Gayman	1967	H	502	H	Oml/sh
702	4014-7726	G. F. Ginter	K. R. Whisler	1970	C	590	S	Omu/shss
703	4013-7718	James Burkholder	Merle L. Gayman	1966	H	472	S	Oml/sh
704	4014-7726	John Moore	K. R. Whisler	1967	H	610	S	Omu/shss
705	4014-7721	Wilbur Lehman	do.	1967	H	575	S	Omu/shss

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Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
150	---	6	---	65	11/71	---	---	13	650	---	Cu-629
82	80	6	---	40	11/71	---	---	---	---	---	630
126	---	6	---	50	11/71	---	---	15	610	---	631
250	175	6	---	---	---	---	---	8	450	---	632
85	20	6	---	34	11/71	---	---	11	450	---	633
197	197	8	---	45	11/71	150	---	---	---	---	634
105	---	6	---	26	11/71	---	---	19	750	---	635
50	---	6	---	26	3/72	---	---	---	---	---	636
95	---	6	---	36	11/71	---	---	32	1475	---	637
100	---	6	---	34	11/72	---	---	---	---	---	638
175	20	6	---	---	---	---	---	36	1575	---	639
153	---	6	---	45	12/71	---	4.0	---	---	---	640
100	---	5	---	23	11/71	---	---	15	650	---	641
130	129	6	---	13	12/71	---	---	---	---	---	642
90	---	6	---	58	11/71	---	---	17	580	---	643
148	---	6	---	19	12/71	---	---	---	---	---	644
60	---	6	---	36	11/71	---	---	16	600	---	645
165	---	6	---	49	12/71	---	---	---	---	---	646
360	---	6	---	46	11/71	---	.03	18	615	---	647
218	---	6	---	53	12/71	---	---	---	---	---	648
144	---	6	---	54	11/71	15	---	15	570	---	649
135	---	6	---	---	---	---	---	11	550	---	650
45	---	---	---	27	11/71	---	---	15	720	---	651
185	---	6	---	33	11/71	---	---	18	690	---	653
312	---	6	---	69	11/71	---	---	14	505	---	655
300	---	6	---	55	11/71	---	---	18	660	---	657
135	68	6	---	35	---	180	---	---	---	---	658
80	---	6	---	41	11/71	---	---	18	675	---	659
227	204	6	150;210	94	7/69	15	---	---	---	---	660
48	---	---	---	33	11/71	---	---	---	---	---	661
200	26	6	---	F	---	60	---	---	---	---	662
100	---	6	---	41	11/71	---	---	16	630	5.80	663
177	34	6	175	35	11/57	---	---	---	---	---	664
300	---	6	---	38	11/71	---	---	---	1050	6.90	665
55	26	6	54	21	12/66	30	---	---	---	---	666
---	---	6	---	49	11/71	---	---	---	600	---	667
460	450	6	---	210	3/72	---	---	0	70	---	668
100	---	6	---	72	11/71	---	---	14	550	---	669
---	---	6	---	68	4/72	---	---	---	---	---	670
43	---	---	---	38	11/71	---	---	---	---	---	671
30	---	---	---	6	4/72	---	---	---	---	---	672
144	52	6	53;75;90;112;144	33	8/72	---	5.7	18	650	---	673
60	47	6	43;50	7	8/72	---	10	15	625	---	674
150	24	6	55;90;97;100	32	8/72	---	2.8	---	---	---	675
200	80	6	77;150;180;200	57	9/72	---	1.6	18	760	---	676
199	84	6	80;128;138;148;152	76	9/72	---	1.3	---	---	---	677
260	98	6	---	---	---	1	---	---	---	---	678
345	15	6	---	41	11/72	---	---	---	---	---	679
97	---	6	45;90	9	11/72	35	---	---	---	---	680
49	---	6	---	36	10/72	---	---	---	---	---	681
202	38	6	41;115	30	4/73	---	30	---	610	---	682
520	66	6	170;300;450	68	6/66	7	---	8	295	---	683
55	23	---	12;50	2	5/67	36	---	---	---	---	684
78	20	6	75	20	6/66	50	---	9	330	---	685
90	18	6	75;85	---	---	---	---	8	320	---	686
70	40	6	60;65	---	---	---	---	---	---	---	687
54	---	6	---	16	7/73	---	.3	5	220	---	688
87	34	6	62;79	---	---	---	---	6	220	---	689
80	40	---	---	34	7/73	---	.47	8	285	---	690
76	66	6	72	35	3/68	25	---	---	250	---	691
123	40	6	123	32	9/67	8	---	---	---	---	692
219	---	6	---	17	4/54	200	---	---	---	---	693
80	41	6	75	38	5/67	15	---	---	---	---	694
300	99	6	---	53	10/55	165	---	10	335	---	695
65	36	6	---	18	9/67	36	---	---	---	---	696
225	100	6	---	74	9/58	80	13	---	---	---	697
200	30	6	110;150;180	35	---	---	---	---	---	---	698
122	---	6	82;122	36	9/68	12	---	12	350	---	699
115	21	6	25;112	29	12/66	24	---	12	290	---	700
123	41	6	123	42	5/67	12	---	---	---	---	701
70	30	6	---	---	---	---	---	6	225	---	702
90	42	6	72;90	30	8/66	10	---	10	350	---	703
69	26	6	25;65	15	6/67	40	---	6	270	---	704
65	27	6	25;60	6	1/67	---	.55	---	285	---	705

TABLE 13.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Number	Lat-Long							
Cu-706	4014-7728	Wilbur Lay	K. R. Whisler	1967	H	750	S	Omu/shss
707	4010-7729	Eldon Funk	Eldon E. Funk	---	U	635	S	Omu/shss
708	4013-7728	E. S. Fisher	K. R. Whisler	1966	H	642	S	Omu/shss
709	4010-7729	Eldon Funk	Eldon E. Funk	---	U	650	H	Omu/shss
710	4011-7724	Robert Lehman	K. R. Whisler	1967	H	580	H	Omm/shgw
711	4010-7729	Eldon Funk	Eldon E. Funk	---	H	640	S	Omu/shss
712	4011-7725	Merle Souder	do.	1967	H	535	V	Omm/shgw
713	4010-7729	Eldon Funk	do.	---	U	640	S	Omu/shss
714	4012-7723	Lee Fickes	K. R. Whisler	1968	H	518	S	Oml/sh
715	4010-7729	Eldon Funk	Eldon E. Funk	---	U	648	H	Omu/shss
716	4012-7724	Donald Lehman	K. R. Whisler	1967	H	628	S	Omm/shgw
717	4014-7721	Clark Baer	Merle L. Gayman	1966	H	732	S	Omu/shss
718	4012-7726	Rosco Line	K. R. Whisler	1969	H	518	V	Omu/shss
719	4014-7721	Clark Baer	Merle L. Gayman	---	I	565	W	Omu/shss
720	4012-7726	Donald Jackson	K. R. Whisler	1967	H	615	H	Omu/shss
721	4014-7721	Harold Chestnut	Merle L. Gayman	1968	H	620	S	Omu/shss
722	4012-7727	Edward Gutshall	K. R. Whisler	1967	H	585	W	Omu/shss
723	4014-7721	Raymond Hurley	do.	1967	H	619	W	Omu/shss
724	4013-7727	Paul Stum	do.	1968	H	610	W	Omu/shss
725	4014-7722	Church of God	do.	1966	H	585	S	Omu/shss
726	4013-7729	Benson Stake	Eldon E. Funk	1968	H	630	S	Omu/shss
727	4006-7732	Melvin Alleman	Eldon E. Funk	1967	H	680	S	Oml/sh
728	4012-7728	Carl Clevenger	K. R. Whisler	1968	H	630	W	Omu/shss
729	4006-7732	Elwood Carbaugh	Eldon E. Funk	1968	H	680	W	Oml/sh
730	4012-7731	John Hocker	K. R. Whisler	1967	H	701	S	Omu/sh
731	4007-7732	Charles Baer	do.	1968	H	537	V	Omu/shss
732	4010-7728	John Hocker	do.	---	H	595	H	Omu/shss
733	4008-7731	Thomas Mitchell	do.	1968	H	521	V	Omu/shss
734	4012-7731	P. W. Houck	do.	1948	H	800	S	Omu/shss
735	4009-7731	Emmanuel Lapp	do.	1968	H	628	H	Omu/shss
736	4011-7729	E. L. Oiler	do.	1968	H	595	S	Omu/shss
737	4009-7732	George Hoover	Eldon E. Funk	---	H	643	S	Omu/shss
738	4013-7730	Raymond Russell	K. R. Whisler	1967	H	1070	S	Omu/shss
739	4009-7732	Jay Pyne	do.	1968	H	660	S	Omu/shss
740	4010-7727	Glen Franklin	Eldon E. Funk	1969	H	495	S	Omu/shss
741	4012-7716	T. A. Hair	---	---	H	445	S	Ombl/shc
742	4009-7726	John Barrick	K. R. Whisler	1969	H	575	S	Oml/sh
743	4013-7721	F. L. Ott	Eldon E. Funk	1968	H	640	S	Omm/shgw
744	4009-7727	Wayne Lesher	K. R. Whisler	1966	H	545	S	Oml/sh
745	4011-7731	Leroy Pomraning	do.	1969	H	715	W	Omu/shss
746	4009-7727	Edward Burkett	do.	1968	H	560	H	Oml/ls
747	4012-7730	Lester Forney	do.	1967	H	730	S	Omu/sh
748	4008-7728	Edward Jumper	do.	1969	H	650	H	Oml/sh
749	4010-7733	Melvin Haltman	Eldon E. Funk	1968	H	665	H	Omu/shss
750	4009-7727	Wayne Failor	K. R. Whisler	1966	H	550	S	Oml/sh
751	4010-7733	Melvin Haltman	Merle L. Gayman	1966	U	660	H	Omu/shss
752	4008-7728	Steward Kyle	K. R. Whisler	1967	H	640	S	Oml/sh
753	4009-7733	Gene Mellinger	do.	1968	H	670	H	Omu/shss
754	4008-7728	Emory Graham	do.	1966	H	650	H	Oml/sh
755	4008-7734	Fred Franklin	do.	1968	H	605	S	Omu/sh
756	4010-7725	John Hoover	do.	1968	H	550	S	Oml/sh
757	4008-7733	Vernon Baker	Eldon E. Funk	1968	H	590	S	Omu/shss
758	4010-7726	Roger Hoover	Merle L. Gayman	---	H	640	H	Omm/shgw
759	4008-7733	Daniel Laughlin	Eldon E. Funk	1968	H	599	S	Omu/shss
760	4010-7725	William Russell	Merle L. Gayman	1966	H	620	S	Omm/shgw
761	4008-7733	Lloyd Coleman	K. R. Whisler	1968	H	570	S	Omu/shss
762	4010-7724	Ronald Cramer	do.	1968	H	555	S	Oml/sh
763	4007-7733	Roy Mohn	do.	1966	H	545	S	Omu/shss
764	4010-7722	Carl Mixell	do.	1968	H	615	S	Oml/sh
765	4007-7733	Wilbur Shoke	Eldon E. Funk	1968	H	560	H	Omu/shss
766	4010-7724	Herbert Shugart	K. R. Whisler	1966	H	495	W	Oml/sh
767	4008-7733	Donald Stewart	do.	1968	H	570	W	Omu/shss
768	4013-7725	Raymond Hosfelt	do.	---	S	525	V	Omu/shss
769	4008-7732	Harry Pauley	do.	1968	H	635	S	Omu/shss
770	4012-7724	Jack Yingling	Merle L. Gayman	1967	H	650	H	Omu/shss
771	4008-7732	W. F. Frotscher	K. R. Whisler	1968	H	605	H	Omu/shss
772	4015-7711	Thomas Wagner	Merle L. Gayman	1967	H	460	S	Oml/sh
773	4008-7733	A. W. Minick	Eldon E. Funk	1966	H	600	S	Omu/shss
774	4014-7710	Richard Magee	Merle L. Gayman	1966	H	440	S	Oml/sh
775	4008-7733	William Minnick	Eldon E. Funk	1968	H	600	S	Omu/shss
776	4016-7709	M. E. Sparr	---	1952	H	485	V	Oml/sh
777	4007-7732	Jay Myers	K. R. Whisler	1968	H	565	S	Omu/shss
778	4015-7707	Ritter Brothers	Harrisburg's Kohl Bros.	1973	H	424	F	Omac/ls
779	4006-7732	Kermit Laidig	Eldon E. Funk	---	H	600	S	Omm/shgw
780	4014-7713	Paul Hoover	Merle L. Gayman	1966	H	490	S	Oml/sh
781	4007-7731	J. O. Petersheim	---	---	H	665	W	Oml/sh
782	4015-7714	Vernon Nailor	Alfred H. Hollenbaugh	1966	H	550	S	Oml/sh
784	4014-7714	Mary Darr	Merle L. Gayman	1967	H	449	V	Oml/sh
785	4014-7714	Warren Corble	do.	1966	H	458	S	Oml/sh
786	4013-7712	John Murphy	do.	1966	H	505	H	Ombl/shc
787	4013-7712	John Horner	do.	1966	H	455	S	Ombl/shc
788	4015-7712	Kenneth Carpenter	do.	1967	H	490	S	Oml/sh

(CONTINUED)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hard-ness (gpg)	Specific conduc-tance (micro-mhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
86	30	6	35;83	15	3/67	24	---	5	185	---	Cu-706
142	---	6	---	24	8/73	---	1.8	4	165	---	707
115	31	6	20;50;110	6	8/66	15	---	---	---	---	708
76	---	6	---	40	8/73	---	2.2	---	---	---	709
65	21	6	40;62	23	5/67	24	---	5	170	---	710
---	---	6	---	34	8/73	---	5	10	300	---	711
67	20	6	50;65	---	---	---	---	21	600	---	712
---	---	6	---	33	8/73	---	---	---	---	---	713
50	26	6	35;40	11	10/68	48	---	10	320	---	714
---	---	6	---	38	8/73	---	---	---	---	---	715
70	21	6	45;46;67	16	6/67	25	---	11	350	---	716
125	46	6	72;123	32	5/66	15	---	10	350	---	717
55	21	6	35;52	4	3/69	24	---	---	---	---	718
225	60	8	210	---	---	100	---	---	---	---	719
140	17	6	59;136	45	4/67	20	---	10	295	---	720
80	36	6	80	38	8/68	12	---	5	190	---	721
60	25	6	30;56	12	4/67	36	---	10	300	---	722
71	32	6	68	30	1/67	10	---	5	190	---	723
106	46	6	70	46	10/68	4	---	---	---	---	724
187	---	6	30;40;182	125	7/66	---	---	8	340	---	725
72	---	---	45;57	---	---	---	---	9	395	---	726
100	28	6	70;95	---	---	---	---	7	230	---	727
85	20	6	38;90	15	7/68	12	---	11	275	---	728
87	31	6	65;80	---	---	---	---	12	340	---	729
59	30	6	55	20	4/67	30	---	5	165	---	730
56	27	6	40;50	8	11/68	30	---	8	310	---	731
116	---	6	---	---	---	80	---	10	265	---	732
60	21	6	45;55	9	6/68	48	---	9	285	---	733
100	47	6	---	20	---	---	---	4	180	---	734
70	28	6	65	20	10/68	25	---	9	310	---	735
200	19	6	50;55	15	8/68	10	---	1	400	---	736
85	20	6	65;80	18	8/73	---	1.0	9	325	---	737
103	57	6	35;98	23	2/67	10	---	8	220	---	738
60	35	6	22;55	10	4/68	36	---	---	---	---	739
57	20	6	48;55	---	---	---	---	---	---	---	740
275	---	6	---	43	8/73	---	.04	18	570	---	741
135	19	6	80;90	15	2/69	10	---	---	---	---	742
55	24	6	50	---	---	50	---	6	200	---	743
94	37	6	30;91	10	7/66	30	---	---	---	---	744
75	20	6	50;72	5	1/69	15	---	9	320	---	745
133	27	6	40;128	21	6/68	10	---	11	280	---	746
85	43	6	50;80	31	1/67	22	---	5	165	---	747
88	12	6	83	17	3/69	24	---	---	---	---	748
132	40	6	85;110	---	---	25	---	7	230	---	749
199	20	6	40:195	30	9/66	10	---	---	---	---	750
88	39	6	88	---	6/66	15	1.3	7	250	---	751
90	22	6	35;86	34	12/67	20	---	---	---	---	752
66	23	6	60	18	11/68	20	---	9	300	---	753
90	---	---	85	15	8/66	20	---	---	---	---	754
60	20	6	49	25	3/68	25	---	9	275	---	755
60	20	6	55	15	4/68	36	---	---	---	---	756
70	20	6	50;65	---	---	200	---	9	315	---	757
85	40	6	---	27	9/73	---	1.5	9	280	---	758
117	32	6	112	---	---	---	---	10	320	---	759
260	41	6	180;260	34	9/66	12	---	---	---	---	760
72	19	6	40;70	12	3/68	25	---	---	---	---	761
70	20	6	45;65	7	7/68	24	---	9	280	---	762
91	---	6	39;86	12	10/66	20	---	11	340	---	763
90	26	6	55;85	2	5/68	30	---	7	180	---	764
82	20	6	60;80	---	6/68	---	---	---	---	---	765
89	25	6	40;84	23	10/66	25	---	---	---	---	766
76	28	6	26;72	6	5/68	24	---	---	---	---	767
52	---	6	---	13	9/73	---	.24	12	240	---	768
100	28	6	80;95	20	8/68	20	.36	10	320	---	769
635	112	6	78;112	36	6/67	---	0.1	---	---	---	770
95	32	6	90	23	11/68	24	---	11	340	---	771
90	39	6	90	31	4/67	10	---	12	420	---	772
110	30	6	100	---	---	---	---	16	460	---	773
223	38	6	170;223	36	10/66	12	---	12	420	---	774
155	30	6	---	---	---	---	---	12	370	---	775
97	---	6	55;95	---	---	25	---	11	380	---	776
76	29	6	70	22	3/68	36	---	---	---	---	777
341	---	6	---	37	9/73	---	---	9	340	7.55	778
---	---	---	---	---	---	---	---	9	280	---	779
115	37	6	78;115	30	9/66	12	---	5	240	---	780
---	---	6	---	---	---	---	---	10	320	---	781
52	23	6	38;49	21	8/66	18	---	10	315	---	782
70	45	6	70	18	7/67	9	---	8	280	---	784
47	26	6	47	8	7/66	20	---	---	---	---	785
122	46	6	70;120	18	5/66	---	.47	12	450	---	786
72	30	6	70	28	5/66	15	---	12	415	---	787
95	40	6	78;95	28	4/67	---	1.8	10	325	---	788

TABLE 13.

Well location: Number	Well location: Lat-Long	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Cu-789	4015-7711	John Evans	Merle L. Gayman	1968	H	430	S	Oml/sh
790	4015-7707	Ritter Brothers	---	---	S	423	F	Omac/ls
791	4012-7711	C. H. Masland and Sons	Charles H. Eichelberger	1965	U	465	F	Osp/lsdm
792	4005-7719	J. Ziegler	Eldon E. Funk	1971	H	645	S	Ct/ldu
793	4005-7718	Fred Leeds	Merle L. Gayman	---	H	690	S	Ct/ldu
794	4005-7720	Samuel Marshall	Eldon E. Funk	---	H	695	S	Ct/ldu
795	4005-7719	Walter Baldwin	K. R. Whisler	1968	H	712	S	Qc/cygv
796	4005-7718	C. W. Fraken	Eldon E. Funk	1966	H	713	S	Ct/ldu
797	4006-7717	Marlin Rider	Merle L. Gayman	1968	H	600	V	Ct/ldu
798	4006-7717	J. W. Taylor	K. R. Whisler	1968	H	615	S	Ct/cygv
799	4002-7727	Raymond Duncan	Eldon E. Funk	---	H	815	S	Qc/cygv
800	4001-7727	Mark Lipper	do.	---	H	938	S	Qc/gv
801	4007-7713	Paul Bear	K. R. Whisler	1967	H	540	V	Qc/gv
802	4005-7719	Merle Sennett	do.	1969	H	710	S	Qc/gv
803	4007-7711	Donald White	Lloyd M. Brandt	1970	H	532	S	Qc/gv
804	4005-7724	Edward Glass	Eldon E. Funk	---	H	720	V	Qc/gv
805	4004-7724	G. E. Keefer	Merle L. Gayman	---	H	800	S	Ct/ldu
806	4004-7723	Francis Perkins	---	1951	H	769	S	Qc/gv
807	4008-7708	South Middleton Twp.	Moody Drilling Co., Inc.	1973	P	510	V	Ce/slld
808	4009-7717	Hooke & Suter	C. E. Sunday	---	P	592	H	Csg/lsdm
809	4013-7717	Gerald Hamilton	K. R. Whisler	1971	H	515	S	Oml/sh

YORK

Well location: Number	Well location: Lat-Long	Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Yo-641	4012-7653	Tri-County Realty	---	---	P	380	S	Oe/ls
645	4008-7702	Carroll Builders	Charles H. Eichelberger	1970	H	473	S	Ct/ldu
838	4008-7701	W. H. Van Sant	---	---	U	448	C	Ct/ldu
840	4012-7653	V. K. Souders	Harrisburg's Kohl Bros.	1964	H	440	S	Oe/lsdm
843	4012-7650	New Cumberland Army Depot	Charles H. Eichelberger	1972	P	340	W	Oe/ls

(CONTINUED)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
95	52	6	95	22	9/68	8	---	---	---	---	Cu-789
41	---	---	---	27	9/73	---	---	20	600	---	790
355	12	8	27;54;220;250	21	8/65	---	.07	21	720	---	791
150	110	6	130;135	---	---	10	---	---	---	---	792
190	163	6	172;190	52	---	8	---	7	200	---	793
97	80	6	90	---	---	---	---	---	---	---	794
67	60	6	20;60	36	10/68	4	---	---	---	---	795
186	178	6	180	---	---	---	---	---	---	---	796
170	144	6	152;170	30	10/68	15	---	6	185	---	797
86	84	6	60;85	30	9/68	24	---	---	---	---	798
248	247	6	248	---	---	25	---	---	---	---	799
265	213	6	240	---	---	5	---	---	---	---	800
82	38	6	75	45	6/67	8	---	---	---	---	801
155	151	6	156	83	5/69	24	---	---	---	---	802
103	103	6	103	43	12/70	40	---	---	---	---	803
90	88	6	89	---	---	15	---	---	---	---	804
247	220	6	247	58	11/69	10	---	---	---	---	805
157	157	6	---	87	---	---	---	---	---	---	806
298	88	12	65;78;88; 111;148;183	36	2/74	---	240	9	267	7.70	807
243	40	6	---	---	---	---	---	15	395	7.39	808
76	20	6	15;72	---	5/71	36	---	---	---	---	809
COUNTY											
149	---	6	---	55	9/70	---	.06	22	950	---	Yo-641
90	86	6	---	45	10/70	---	23	11	375	---	645
28	---	---	---	26	11/71	---	---	16	645	---	838
180	---	6	---	---	---	18	---	---	690	6.5	840
640	65	8	---	---	---	132	---	---	---	---	843

TABLE 14. RECORD OF SPRINGS

Spring number: A serial number assigned at the time the spring was first visited. Many small springs for which miscellaneous information is available are omitted from this table.

Location number: Degrees, minutes, and seconds of latitude and longitude, respectively.

Hardness: grains/gal, grains per gallon. Multiply by 17.1 to obtain the value in mg/L.

Use: H, domestic; I, irrigation; P, public supply; U, unused; Z, fish hatchery.

Discharge: M, measured; E, estimated; R, reported. Estimated discharge characteristics were determined using all available estimates and measurements.

Spring no.	Location (Latitude-longitude)	Owner (Spring name)	Altitude above sea level (feet)	Geologic unit	Discharge (gal/min)	Date measured or estimated	Estimated discharge characteristics (gal/min) Max.	Med.	Min.	Use	Temperature (°C)	Hardness (grains/gal)	Specific conductance (micromhos at 25°C)	Remarks
Cu-Sp-1	401419 765708	Hampden Twp.	350	Martinsburg Formation	450	E 4-13-70				U	12.8	15	825	
					350	M 11-12-71		400		U				
2	401344 765514	Tora Investment Co. (Eichelberger Spring)	370	St. Paul Group	1450	M 11-05-70				U	14	13	725	Frequently contaminated by surface runoff.
					990	M 11-12-71		1100		U				
3	401339 765507	Marlin Weaver (Spring Lake Spring)	370	St. Paul Group	420	M 11-06-70				I	12.5	13	725	
					290	M 11-12-71		350		I				
4	401428 770025	John F. Ebersole (Silver Spring)	375	Rockdale Run Formation	1690	M 11-06-70				U	12.5	12	600	
					1890	M 11-11-71		1900		U				
5	401158 770153	Robert Weber (Trindle Spring)	430	Shadygrove Formation	960	M 11-06-70				P,I	12.5	12	490	
					730	M 11-11-71		850		P,I				
6, 7	400901 770745 400858 770742	J. B. Bucher (Boiling Springs)	470	Elbrook Formation	18300	M 6-10-44				P	13			Measured discharge is total flow of both springs. Field water-quality characteristics were measured at Sp-6.
					15700	M 7-07-44				P				
					17000	M 2-12-52				P				
					12200	M 8-20-65				P				
					10500	M 1-17-67				P				
					11300	M 12-08-67				P	13			
					10800	M 11-08-71	18000	11500	10000	P		8	280	

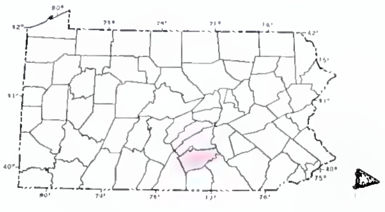
8	400607	771843	Pa. Fish Comm. (Huntsdale Hatchery Spring)	600	Tomstown Formation	320 250	M 7-07-44 M 11-18-71		Z	14.5	5	200	Field water-quality characteristics were measured on 11-20-70.
9	400609	771845	Pa. Fish Comm. (Huntsdale Hatchery Sp. No. 2)	600	Waynesboro Formation	490 275	M 7-07-44 M 11-09-71		Z	11	5	200	Field water-quality characteristics were measured on 11-12-70.
10, 11	400606	771845	Pa. Fish Comm. (Huntsdale Hatchery Sp. Nos. 3 and 4)	605	Tomstown Formation	5100	M 7-07-44 11-12-70		Z	15	5	200	Measured discharge is a composite of both springs.
12	400611	771836	Pa. Fish Comm. (Huntsdale Hatchery Sp. No. 5)	600	Waynesboro Formation	560	M 7-07-44		Z	11	5	220	Field water-quality characteristics were measured on 11-13-70.
13, 14	400604	771837	Pa. Fish Comm. (Huntsdale Hatchery Sp. Nos. 6 and 7)	610	Tomstown Formation	2450 2060	M 7-07-44 M 11-09-71		Z Z	15	5	200	Field water-quality characteristics were measured on 11-13-70 on composite flow.
15	400618	771806	Pa. Fish Comm. (Huntsdale Hatchery Sp. No. 8)	600	Tomstown Formation	1490 720	M 7-07-44 M 11-12-70 11-17-71		U U	14.5	5	190	Total flow of Huntsdale Hatchery springs was 11,600 gal/min on 11-17-71.
16	401003	771553	Paul E. Wyrick (Alexander Spring)	530	Stonehenge Formation	1350 910	M 11-13-70 M 11-12-71	1100	U U	12 11.3	13	520	
17	400941	771859	Sidney A. Capon (Mountrock Spring)	525	Shadygrove Formation	1500 840	E 11-13-70 M 11-12-71	1000	U U	12	12	530	
18	401009	771840	(Unnamed spring)	520	Stonehenge Formation	800 660	M 11-13-70 M 11-11-71	750	U U	12	12	375	Field water-quality characteristics were measured on 11-13-70.
19	401241	771005	U. S. Government	435	St. Paul Group	1740 1180	M 11-16-70 M 11-08-71	1400	P P	12.5	17	615	Field water-quality characteristics were measured on 12-20-71.
20	401252	771023	U. S. Government	435	St. Paul Group	1800	E 11-16-70	1400	Z	13	14	750	

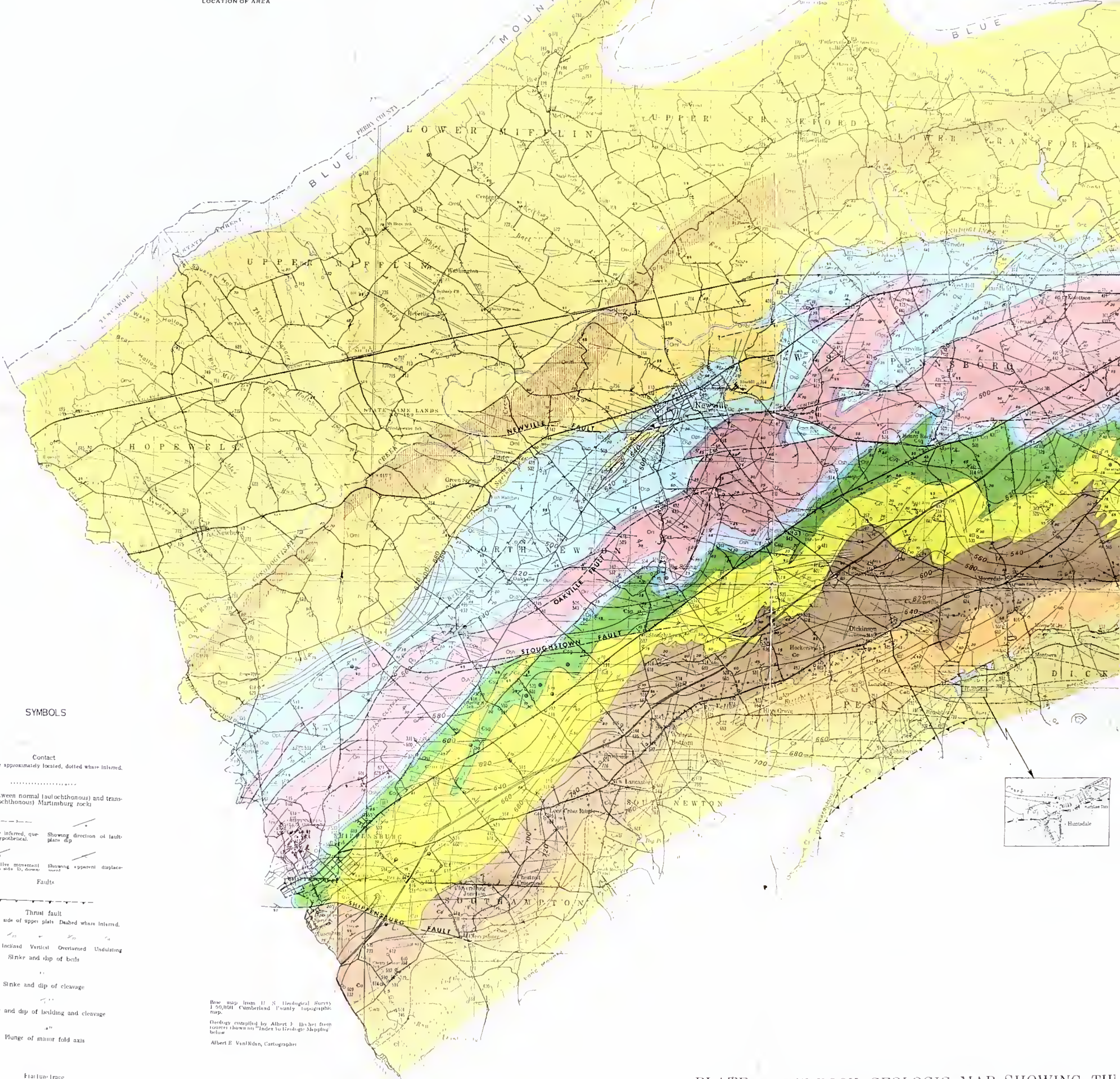
TABLE 14. (CONTINUED)

Spring no.	Location (Latitude-longitude)	Owner (Spring name)	Altitude above sea level (feet)	Geologic unit	Discharge (gal/min)	Date measured or estimated	Estimated discharge characteristics (gal/min) Max.	Med.	Min.	Use	Temperature (°C)	Hardness (grains/gal)	Specific conductance (micromhos at 25°C)	Remarks
Cu-Sp-21	401240 770955	G. R. Keim	435	St. Paul Group	1000	E 11-08-71				U				
22	400744 772429	Pa. Fish Comm. (Big Spring)	530	Stoufferstown Formation	13900	M 6-09-44				U	12			
					12900	M 7-07-44				U				
					12000	M 8-17-49				U				
					10800	M 8-20-65				U	11			
					7500	M 1-13-67				U	11			
					8200	M 1-17-67				U	11			
					10300	M 10-16-67				U	11			
					12000	M 10-05-71				Z				
					11400	M 11-11-71	15000	12500	6000	Z	10.9	8	405	Field water-quality characteristics were measured on 12-20-71.
23	400841 772745	Robert Strohm (Green Spring)	510	Chambersburg Formation	1400	E 10-28-70				Z				
					2500	E 11-17-70				Z	11.5	18	700	
					900	M 11-11-71		1300		Z				
24	400231 773056	Shippensburg Bor. (Dykeman Spring)	665	Elbrook Formation	1450	M 7-06-44		900			11.5			
					690	M 11-10-71				P	11.5	7	240	
25	401018 772338	Newville Bor. (Cool Spring)	485	St. Paul Group	320	E 8-11-71		450		P	11	15	750	
26	400603 771840	Pa. Fish Comm. (Huntsdale Hatchery Sp. No. 9) (Bucher Spring)	610	Tomstown Formation	850	M 9-22-71				Z	14	5	250	
					775	M 11-09-71		750		Z				
27	401056 765659	W. T. Bryan, Jr.	402	Epler Formation	<100	E 9-15-70				H	11.7	15	490	

28	400918 772637	John Hostetter	512	St. Paul Group	200	E 8-17-71		H		15	550	
29	401248 770638	I. M. Glace, Jr. (Hidden Spring)	450	Pinesburg Station Formation	26	M 11-11-71	30	H	9.3	14	560	Field water-quality characteristics were measured on 2-29-72.
30	400943 770050	Edward LaFond	450	Elbrook Formation	1460	M 11-11-71	1700	U	11			
31	400933 770603	(Baker Spring)	475	Elbrook Formation	1800	E 7-13-75		Z	11	13	490	Field water-quality characteristics were measured on 4-21-72.

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*


LOCATION OF AREA



SYMBOLS

Contact
Dashed where approximately located, dotted where inferred.

Contact between normal (autochthonous) and transported (allochthonous) Martinsburg rocks

Dashed where inferred, queried where hypothetical.

Showing direction of fault-plane dip

Showing relative movement U, upthrown side; D, downthrown side

Showing apparent displacement

Faults

Thrust fault
Sawteeth on side of upper plate. Dashed where inferred.

Horizontal Inclined Vertical Overturned Undulating
Strike and dip of beds

Strike and dip of cleavage

Strike and dip of bedding and cleavage

Plunge of minor fold axis

Fracture trace
Obtained from aerial photographs, not field checked

Well location and county number

Observation well having continuous water level recorder

Spring location and county number

Location and number of stream-gaging station having a continuous record

Water level contour on November 6-11, 1972, in carbonate rocks
Contour interval 20 feet. Dashed where approximately located

Well or spring location and water level
Water level is in feet above National Geodetic Vertical Datum of 1929

Groundwater divide

Groundwater barrier (geologic)

Base map from U. S. Geological Survey 1:50,000 Cumberland County topographic map.

Geology compiled by Albert E. Becher from sources shown on "Index to Geologic Mapping" below

Albert E. VanOlden, Cartographer

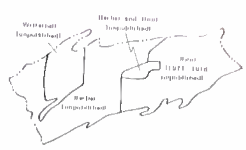

INDEX TO GEOLOGIC MAPPING

PLATE 1. BEDROCK GEOLOGIC MAP SHOWING THE ... OF THE NORTHERN PART OF THE CUMBERLAN... CUMBERLAND COUNTY, PENNSYLVANI...

BY ALBERT E. BECHER AND SAMUEL I. ROOT

1981

Scale 1:50,000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

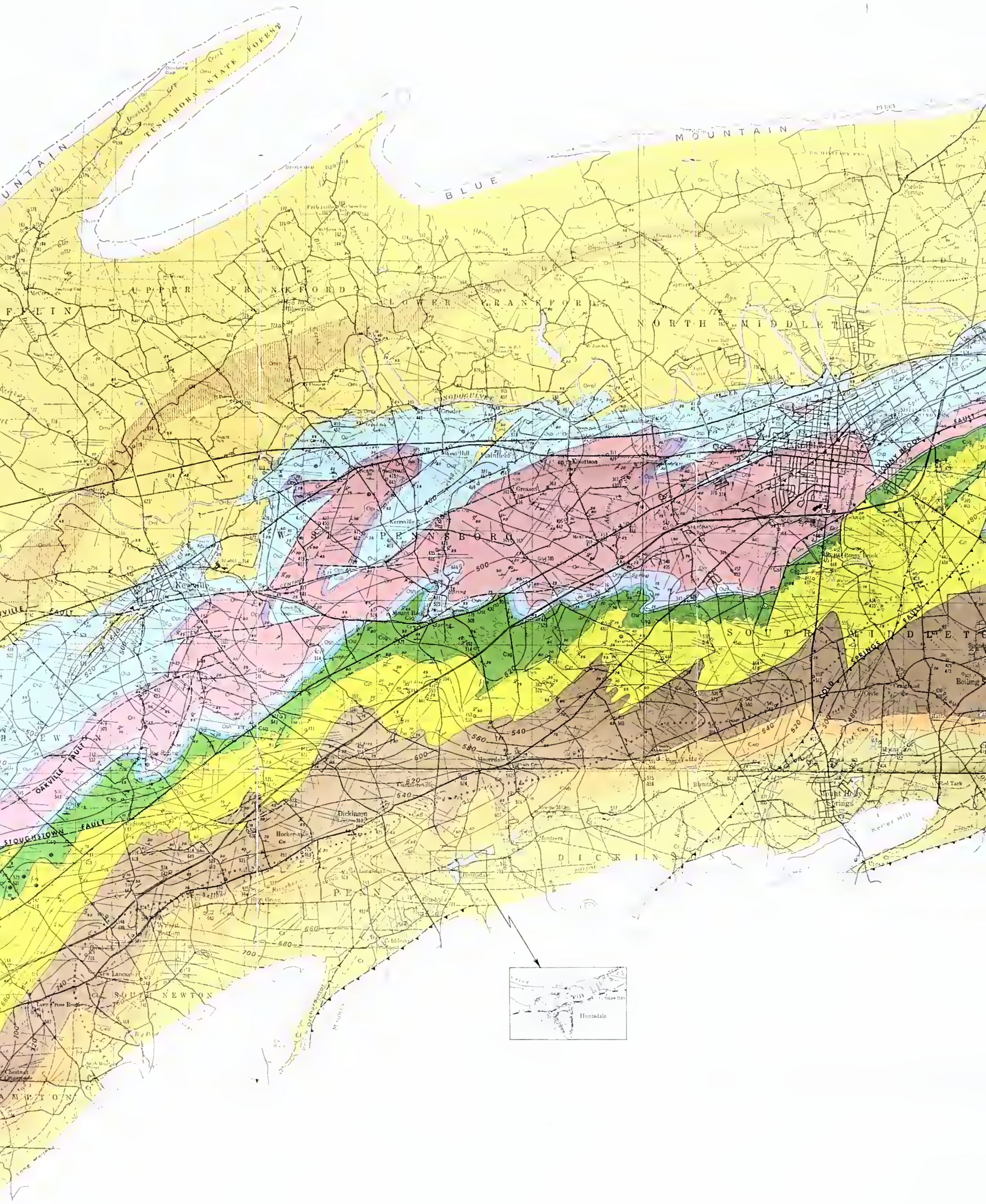


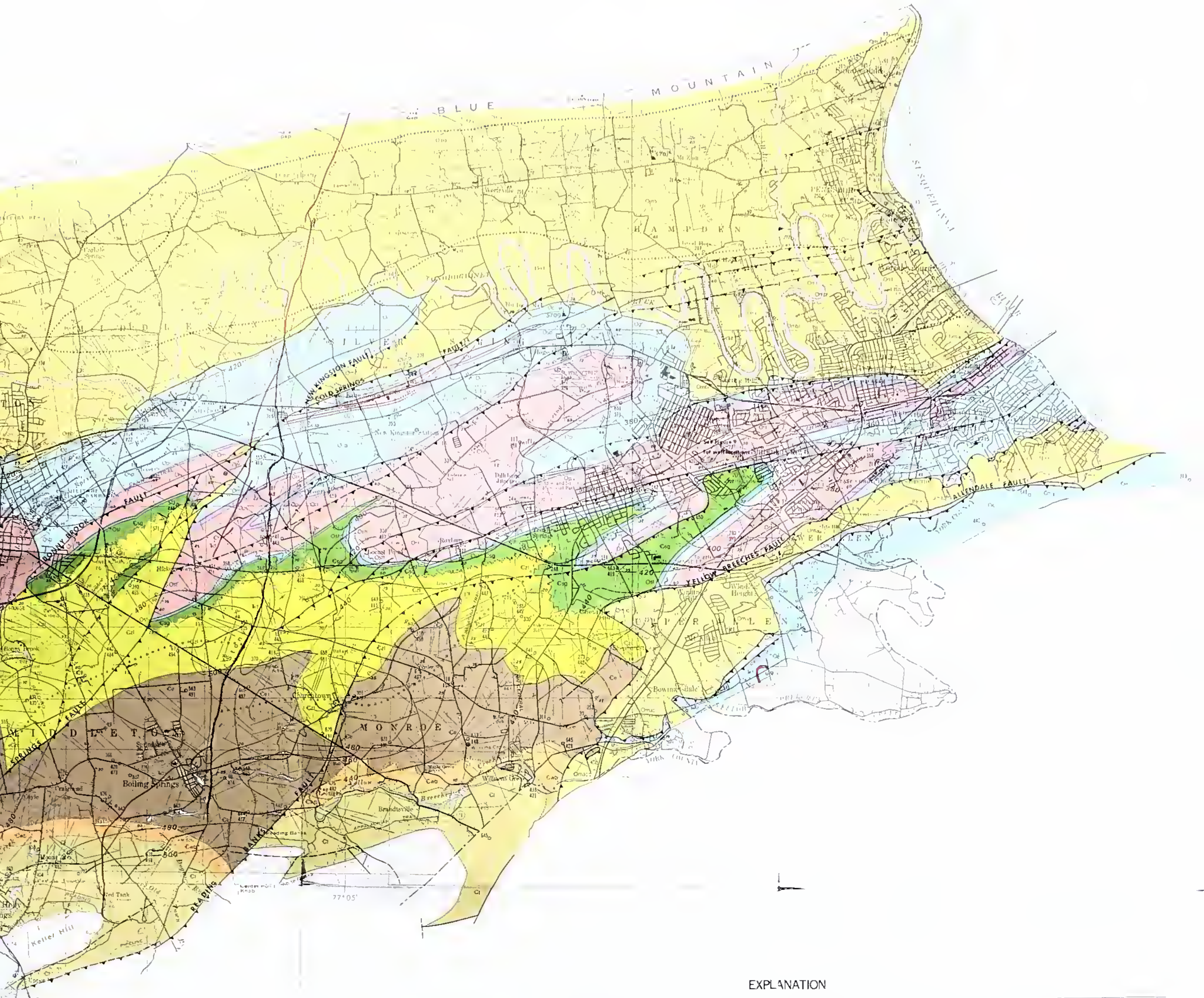
PLATE 1. BEDROCK GEOLOGIC MAP SHOWING THE HYDROLOGY OF THE NORTHERN PART OF THE CUMBERLAND VALLEY, CUMBERLAND COUNTY, PENNSYLVANIA

BY ALBERT E. BECHER AND SAMUEL I. ROOT

1981

Scale 1:50,000

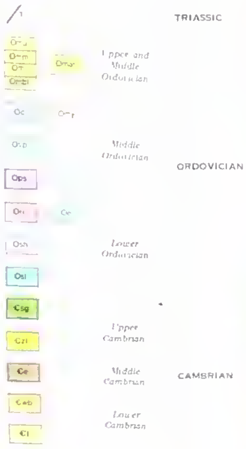
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



EXPLANATION

FORMATION OR GROUP	GEOLOGIC DESCRIPTION	HYDROLOGIC PROPERTIES	ENGINEERING PROPERTIES
DIABASE Trd	Diabase dike is composed of fine-grained plagioclase feldspar and dark pyroxene; forms Stony Ridge; about 75 feet thick where best exposed.	No yield data are available for wells in this unit. Yields adequate to supply domestic needs are unlikely. The dike forms a barrier to ground-water movement in the carbonate aquifer.	Good-quality foundation for heavy structures, very difficult to excavate, requiring blasting, difficult to drill because of extreme hardness.
MARTINSBURG FORMATION, AUTOCHTHONOUS (NORMAL) Omu Omm Oml Ombl	Upper member (Omu) and lower member (Oml): buff-weathering, dark-gray shale and thin interbeds of siltstone, metabentonite, and fine-grained graywacke. Siltstone beds are more abundant in upper part. Several hundred feet of thick to massive, brown-weathering, medium-grained graywacke (Omm) containing shale and siltstone interbeds separate upper and lower parts. Basal Martinsburg (Ombl): grades from dark-gray, limy shale down to thin-bedded, platy-weathering, dark-gray, argillaceous limestone; shown on map only where extensively exposed, generally is 50 to 150 feet thick west of Carlisle, and thickens eastward from Carlisle.	The median specific capacity of wells in all units except the basal limestone is 1.78 (gal/min)/ft. A median sustained yield of 32 gal/min is calculated for these units, and a maximum well yield of 200 gal/min is reported. Yielding zones are commonly less than 100 feet in depth but occur as deep as 350 feet. The median specific capacity and median sustained yield of the basal limestone (Ombl) are 0.15 (gal/min)/ft and 5 gal/min, respectively. The natural quality of water from this limestone is often poor because of H_2S and high concentrations of Fe.	Generally good quality foundation for heavy structures, should be excavated to sound rock; limestone is suitable for light to medium structures, and sinkhole investigation should be made. Moderately easy excavation in shale; moderately difficult in limestone, possibly requiring blasting; difficult in graywacke, requiring blasting and heavy power machinery. Fair cut-slope stability, but moderate to gentle cuts are necessary; graywacke generally has good cut-slope stability and will maintain fairly steep cuts.
MARTINSBURG FORMATION, ALLOCHTHONOUS (TRANSPORTED) Omac ls cs gr	Allochthonous units (Omac) predominate east of Carlisle, including local fine-grained graywacke, greenish-gray phyllitic shale, maroon and green mudstone, platy-weathering, thin-bedded, argillaceous limestone (ls) bodies, coarse-grained graywacke (gr), calcareous sandstone (cs), and some melange masses of varied lithology. Some normal (autochthonous) rocks may be present in the Yellow Breeches fault block. Thickness of Martinsburg is unknown.	Noncarbonate rocks of this unit (Omac) have a median specific capacity of 0.42 (gal/min)/ft and a calculated median sustained yield of 15 gal/min. Carbonate lenses have a median specific capacity of 1.4 (gal/min)/ft and a calculated median sustained yield of 48 gal/min. Maximum known well production from this unit is 90 gal/min. Yielding zones are evenly distributed to depths of 200 feet.	Generally good quality foundation for heavy structures, should be excavated to sound rock; limestone is suitable for light to medium structures, and sinkhole investigation should be made. Moderately easy excavation in shale; moderately difficult in limestone, possibly requiring blasting; difficult in graywacke, requiring blasting and heavy power machinery. Fair cut-slope stability, but moderate to gentle cuts are necessary; graywacke generally has good cut-slope stability and will maintain fairly steep cuts.
CHAMBERSBURG FORMATION Oc	Dark-gray, thin- to medium-bedded, nodular limestone and minor units of thin, even-bedded, argillaceous limestone, thin bands of metabentonite, forms gentle lowlands; 650 feet thick.	Median specific capacity is 0.2 (gal/min)/ft and calculated median sustained yield is 11 gal/min. Yielding zones are developed best above 100-foot depth, although zones occur at least to 400 feet. The occurrence of H_2S and Fe is common in water from this unit.	Good-quality foundation for light to medium structures, should be excavated to sound rock and investigated for sinkholes. Moderately easy excavation with heavy power equipment; requires blasting in sound rock. Fair cut-slope stability, maintains fairly steep slope
MYERSTOWN FORMATION Omy	Thin, even-bedded, platy-weathering, medium-dark- to dark-gray, fine-grained, dense limestone which weathers medium gray with a bluish cast, unit is bounded by faults. A thickness of only a few tens of feet is present in the county.	Insufficient data are available to evaluate the unit in this area. It is probably similar to the Chambersburg Formation, which it resembles.	Good-quality foundation except for light to medium structures. Moderately easy excavation with heavy power equipment; blasting is required in unweathered rock. Moderate slope cuts are necessary to maintain long-term stability; landslides are possible.
ST. PAUL GROUP Osp	Light-gray, thick-bedded, high-calcium, "birdseye" micritic limestone having prominent beds and medial zone of medium-gray, granular, black-chert-bearing limestone, dolomite, and skeletal-detrital limestone, forms gentle lowlands, 600 to 900 feet thick.	Median specific capacity is 1.4 (gal/min)/ft and calculated median sustained yield is 82 gal/min. Maximum sustained yield of an existing production well is 260 gal/min.	Good-quality foundation for light to medium structures; should be investigated for sinkholes. Difficult excavation, requires blasting and heavy power machinery; bedrock pinnacles are a problem. Maintains stable slopes in steep to near vertical cuts, steeply dipping beds inclined to roadway require moderate to fairly steep cuts.
PINESBURG STATION FORMATION Ops	Thick-bedded, light- to medium-gray, laminated to banded dolomite that contains sparse black chert nodules and small white quartz nodules; has interbeds of blue-gray limestone that increase in abundance westward; forms gentle lowlands, 175 to 300 feet thick.	Insufficient data are available to evaluate this unit; it is probably one of the poorer units in this carbonate rock sequence.	Good-quality foundation for heavy structures; possible development of caverns, but not as extensive as development in adjacent units. Difficult excavation; blasting is required and disposal of large blocks is a problem; chert lenses may slow moderate rotary drilling rates. Good cut-slope stability, will maintain vertical cuts.
ROCKDALE RUN FORMATION Orr	Lower third is composed of medium-bedded, finely laminated to homogeneous, chert-bearing micritic limestone and stromatolitic limestone very light gray with a pinkish cast; upper two thirds is composed of light-gray, medium- to thick-bedded, detrital to detrital-skeletal and micrograined limestone. Abundant dolomitic laminae and sparse dolomite interbeds; bioturbated white-quartz-nodule-bearing beds near top; forms rolling lowlands, estimated to be 2,000 to 2,500 feet thick; locally extends to top of Stoufferstown and contains floating quartz sand where Stonehenge is not developed.	Median specific capacity is 12 (gal/min)/ft and calculated median sustained yield is 105 gal/min. The maximum sustained yield reported for the unit is 600 gal/min. Most yielding zones are less than 100 feet in depth.	Good-quality foundation for heavy structures, should be investigated for cavern development; local intense pinnacle development. Difficult excavation; blasting and medium to heavy power machinery are required; chert in upper part slows moderate rotary drilling rate. Good cut-slope stability, will maintain steep to near vertical cuts.
EPLER FORMATION Oe	Medium- to thick-bedded, light- to medium-gray, laminated, finely crystalline limestone containing interbeds of medium-dark-gray dolomite and dolomitic limestone; unit is bounded by faults. A thickness of only a few hundred feet is present in the county.	Insufficient data are available to evaluate the unit in this area, it is probably similar to the Rockdale Run Formation, which it resembles.	Good-quality foundation for heavy structures; should be excavated to sound bedrock and investigated for caverns. Difficult to excavate, requires blasting and heavy power equipment; bedrock pinnacles are a special problem. Usually has good cut-slope stability; near vertical cuts are possible.
STONEHENGE FORMATION Osh	Poorly exposed, light- to medium-gray, micrograined to micritic limestone containing zones and beds that are detrital to skeletal-detrital; some pinkish chert-bearing limestone beds increase in abundance westward; forms rolling lowlands. Estimated to be 500 feet thick but is locally absent between Carlisle and Mechanicsburg.	Although scanty, data indicate a median specific capacity of 2 (gal/min)/ft for wells in this unit. A median sustained yield of 57 gal/min is calculated for the formation. The maximum sustained yield from a production well is 125 gal/min. The greatest development of yielding zones is at depths less than 100 feet.	Good-quality foundation for heavy structures; should be investigated for cavern development. Difficult excavation, requires blasting and medium power machinery; bedrock pinnacles are a problem, moderate rotary drilling rate. Good slope stability; generally maintains near vertical cuts.
STOUFFERSTOWN FORMATION Ost	Prominent ridge former characterized by steep to moderate slopes, composed of detrital limestone containing medium to thick beds of edgewise conglomerate, thin, medium- to dark-gray siliceous seams are abundant; estimated to be 200 feet thick but locally is absent between Carlisle and Mechanicsburg.	Data are insufficient to evaluate this unit, it is thought to be one of the poorest yielding units in the carbonate rock sequence.	Moderately good quality foundation for medium structures; should be excavated to sound rock; slight possibility of cavern development. Difficult excavation; requires blasting and yields large blocks, as a ridge former it will require considerable excavation to yield a suitable large site. Moderate cut-slope stability, will maintain steep cuts, but some argillaceous bands may cause slide problems.
SHADYGROVE FORMATION Csg	Light-gray to pinkish-gray micritic limestone, stromatolitic in part, abundant nodules of brown chert, some beds of finely detrital limestone and a few beds of sandstone, a few beds of finely laminated dolomitic limestone and dolomite, some beds of Zullinger lithology; it is frequently difficult to select base of unit; forms gently rolling lowlands; estimated thickness is 800 to 1,000 feet.	The median specific capacity of 0.46 (gal/min)/ft indicates that this is a poor-yielding formation. A median calculated sustained yield of 26 gal/min is estimated for the unit.	Good-quality foundation for heavy structures, but should be thoroughly studied as it may be cavernous. Difficult excavation, requiring blasting; bedrock pinnacles are a problem; thin sandstone interbeds and chert nodules will slow the normally moderate rotary-drilling rate. Good cut-slope stability; will maintain near vertical cuts.
ZULLINGER FORMATION Czl	Composed of thick beds of medium-gray, sand- to pebble-sized detrital limestone, stromatolitic limestone, and banded limestone containing siliceous seams, some thick beds of dolomite and calcareous sandstone; forms rolling hills and valleys of moderate relief and slope with some prominent, steep ridges supported by sandstones. In upper part, beds of light-gray micritic limestone of Shadygrove aspect occur, thickness is estimated to be 2,500 feet.	Median specific capacity is 1.5 (gal/min)/ft and calculated median sustained yield is 82 gal/min. Distribution of yielding zones with depth ranges little to 450 feet, the maximum depth for which data are available.	Good-quality foundation for heavy structures, but valleys should be examined for caverns and pinnacles. Difficult excavation; requires blasting and heavy power machinery; sandstone beds will slow drilling rate and cause bit wear. Will maintain near vertical cut slopes.
ELBROOK FORMATION Ce	Interbedded calcareous shale, argillaceous limestone and limestone in beds a few to scores of feet thick; bedding is cleavage-dominated to transposed (reoriented); local calcareous sandstone and siltstone beds up to several feet thick; forms hills of moderate relief and gentle slope; estimated to be 3,500 feet thick.	Median specific capacity is 3.8 (gal/min)/ft and calculated median sustained yield is 218 gal/min. An existing production well has a sustained yield of 2,000 gal/min. Yielding zones decrease significantly below depth of 150 feet.	Good-quality foundation for light to medium structures and locally heavy structures on massive carbonate rocks, should be excavated to sound bedrock. Shaly portion is moderately easily excavated with medium to heavy power equipment; massive limestones require blasting and heavy power equipment; slow drilling rate in local sandstones may cause damage to bit; should be investigated for sinkholes and pinnacle development. Massive limestones will maintain near vertical cut slopes, but shaly portions maintain only moderate slopes.
WAYNESBORO FORMATION Cwb	Thick-bedded, laminated, fine- to coarse-grained, well-sorted, quartzitic sandstone containing thin interbeds of medium- to dark-gray, silty mudstone; probably includes some interbeds of carbonate rocks having prominent cleavage, but unit is poorly exposed; forms ridge of moderate relief and moderate slope; estimated to be 1,000 to 1,500 feet thick.	Scanty data indicate a median specific capacity of about 5.7 (gal/min)/ft and a calculated median sustained yield of 172 gal/min for this formation.	Good-quality foundation for heavy structures but should be excavated to sound bedrock. Difficult excavation, requires blasting and medium power equipment; slow drilling rate in tough sandstone. Probably will maintain steep to near vertical cut slopes, but where jointing is well developed slumping and rockfalls will occur.
TOMSTOWN FORMATION Ct	Covered with alluvium and colluvium throughout county; some thick massive dolomites are present in middle of unit; limestone, siltstone, claystone, and thin claystones probably occur in lower part and possibly in upper part. Thickness is estimated to be 1,000 to 2,000 feet.	Median specific capacity is 19 (gal/min)/ft and calculated median sustained yield is 1,050 gal/min. Production wells sustain yields of up to 1,300 gal/min. Yielding zones are evenly distributed through the upper 200 feet of bedrock. Colluvium provides groundwater storage for the unit but may also create drilling and developing problems.	Areas underlain by dolomite form good-quality foundation for heavy structures; areas underlain by limestone will support heavy structures only if they have extensive foundation systems, because of intense sinkhole and pinnacle development; siltstone and claystone are deeply weathered and will support medium structures, but should be excavated to sound bedrock, or pilings should be used. Drilling and excavation are difficult in limestone and dolomite, requiring blasting and heavy power equipment. Cut-slope stability is poor in weathered shale and claystone, but steep to vertical slopes are maintained in dolomite and some of the limestone.

CORRELATION OF MAP UNITS



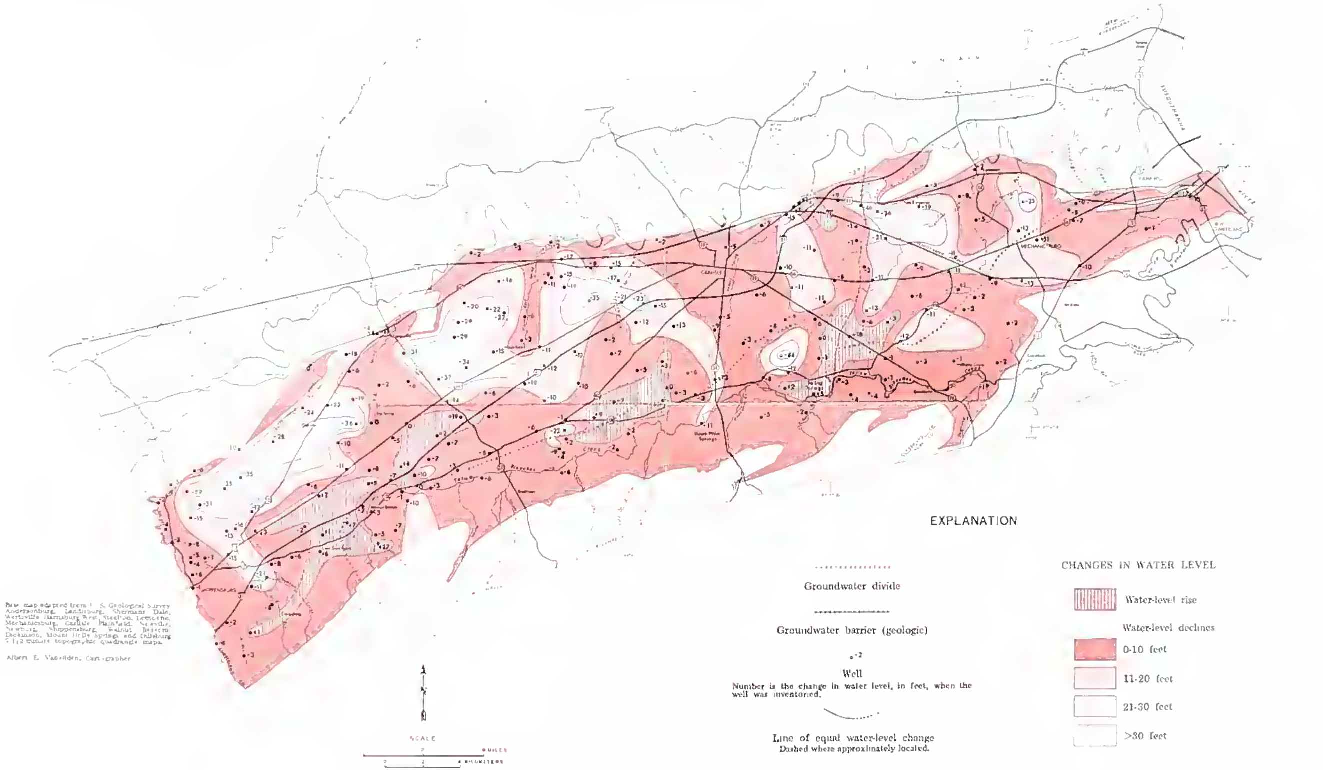


PLATE 2. CHANGE IN GROUNDWATER LEVELS BETWEEN MARCH AND NOVEMBER 1972 IN CARBONATE ROCKS OF THE NORTHERN PART OF THE CUMBERLAND VALLEY

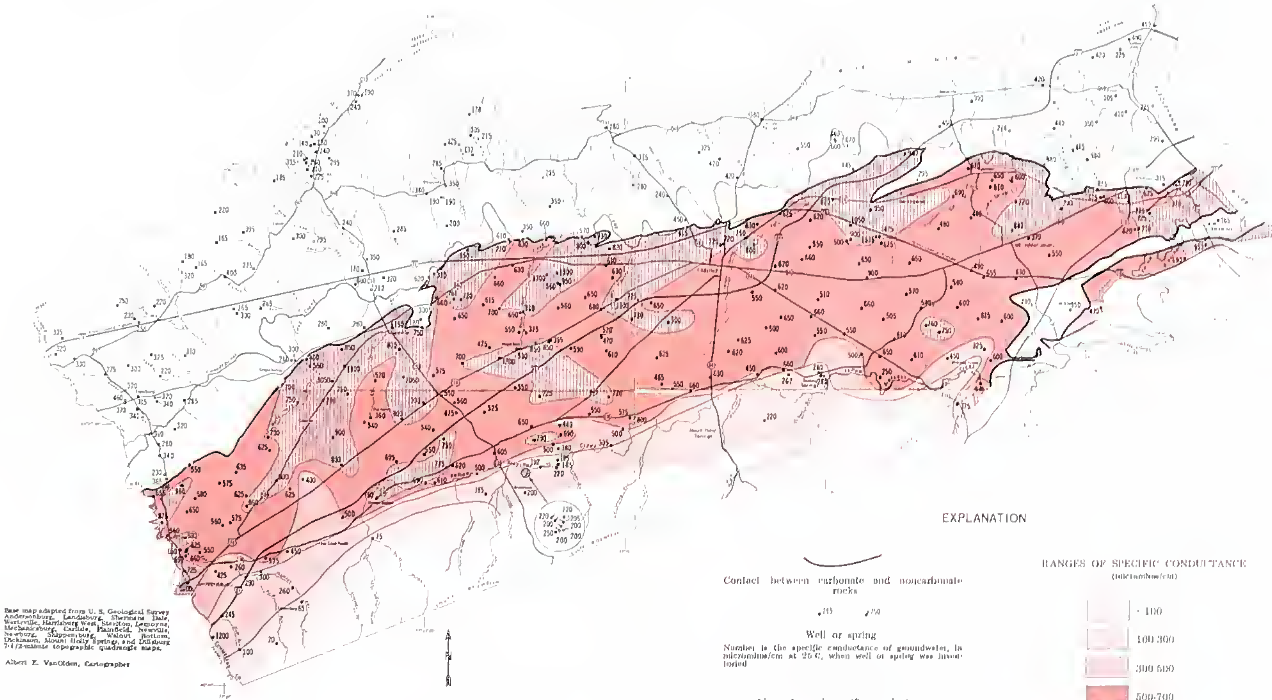


PLATE 3. DISTRIBUTION OF SPECIFIC CONDUCTANCE OF GROUNDWATER IN THE NORTHERN PART OF THE CUMBERLAND VALLEY